UNIVERSITY COLLEGE OF WALES,
ABERYSTWYTH

WELSH PLANT BREEDING STATION

REPORT

1st October 1956 to 30th September 1958

PLAS GOGERDDAN, ABERYSTWYTH
1959

PRICE — 7/6

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Manager, Morfa Mawr Seed Multiplication Farm : GLYNDWR PHILLIPS, Dip. Agric.

VISITING RESEARCH WORKERS

Mr. M. M. Habib, University of Alexandria, Egypt, completed his work on Genetical Studies in lucerne (*Medicago* spp.), and was awarded the degree of Ph.D. Univ. Wales, October 1958.

Mr. A. S. Patel, Anand, Bombay State, India, completed his work on Studies on the pattern of vegetative growth in populations of *Lolium* and *Phleum*, and its genetic and environmental control, and was awarded the degree of Ph.D. Univ. Wales, June 1958.

Mr. Claude D. C. Pfitzenmeyer, University of Paris, working on the autecology of *Arrhenatherum*, May 1957–

Mr. Per Nils Lundin, Weibullsholm, Landskrona, Sweden, a British Council Scholar, attached to the Cereal Breeding Section from October, 1957, to September 1958.

Professor Vinko Sadar, University of Ljubljana, Yugoslavia, British Council Scholar, Grass Breeding Section from September 1957, to July 1958.

Dr. Lionel Dessureaux, Ministère de l'Agriculture, Station Expérimentale, Ste. Anne de la Pocatière, Quebec, Canada, Legume Breeding Section, October 1957.

Mrs. A. Soteriadou, Department of Agriculture, Nicosia, Cyprus, June to August 1958.

Professor D. A. Roberts, Cornell University, Ithaca, New York, U.S.A., with a grant from the Guggenheim Memorial Foundation, February to April 1958.

Mr. Osman H. Sarič, Assistant at Institute for Agricultural Research, Sarajevo, Yugoslavia, F.A.O. Fellowship, May to November 1958.

PREFACE

Professor E. T. Jones retired in September 1958 after 36 years' service, 28 of which were in the capacity of Research Officer in charge of investigations with oats, a work which he accomplished with outstanding success. As Director from 1950 to 1958 he was responsible for the further development of the Station, especially when the new Headquarters moved to Gogerddan in 1953.

The present report records the work of the Station during the last two years of Professor E. T. Jones's directorship, and much of it was prepared while he was still in office. It covers the period 1st October 1956, to 30th September 1958, and gives an account of fundamental and applied research in progress, including some new studies and supplementary data on experiments described in the Report for 1950–1956.

The investigations are concerned with the production of improved and better-adapted varieties of grasses, herbage legumes and cereals (chiefly oats), and also with the study of their agronomic behaviour under upland and lowland conditions.

We wish again to express thanks to collaborators in the Department of Agricultural Botany, U.C.W., Aberystwyth, and also in the N.A.A.S. and N.I.A.B.

In future, it is proposed to publish annually a report on the work of the Station, and that for 1959 it is hoped will appear in the spring of 1960.

GRASS BREEDING

A. R. Beddows

During the period under review the emphasis has been on the potential varieties. Parent/progeny reactions have been used to indicate the better combiners within each group and the selected plants have been clonally multiplied and planted in isolation to provide sufficient seed for agronomic tests.

The following potential varieties are under study :

S.230	*Phalaris*, the hybrid derivative canary grass
S.55	Meadow foxtail for spring and mid-summer production
Ba 6280	Perennial ryegrass for late autumn and summer-gap production
Ba 6293	Perennial ryegrass for late winter and early spring keep
Bd 2308	Timothy, erect hay, or mid-summer grazing
Bm 102	Tall oat grass, pasture hay
Bc 4075	Early fodder cocksfoot

In addition seed from two diploid varieties of *Dactylis* was harvested in 1957, Bc 4651, from plants selected from Portuguese material possessing high resistance to winter burn, and Bc 4656, derived from interpollination in isolation of the Portuguese plants and *D. aschersoniana* (M.B.). These seeds will be used for comparison in Stage 1 agronomy sward trials.

Genetical assessment of parental material : the statistical treatment of data from F_1 and I_1 deriving from a diallel cross in *L. perenne* (A. R. B. and E.J.L.)

The preliminary aspects of this investigation were referred to in the 1950–56 Report. The data obtained in 1956 for green hay and aftermath weights, the number of inflorescences in each cut, as well as the date of inflorescence emergence, have been analysed by the methods of Dickinson and Jinks.[1]

A brief summary of the results of this analysis was presented at the Plant Breeders' Conference, Aberystwyth, July 1958, namely, that the characters hay and aftermath production, considered the most important, showed high average dominance uncomplicated by non-allelic interaction, indicating that there was no evident specific

[1] Dickinson, A. G. and Jinks, J. L. 1956. A generalised analysis of diallel crosses. *Genetics*, 41, 65–78.

combining ability. This implies that improvement could be achieved by the accumulation of favourable dominant alleles. That this is so appears to be borne out by the fact that the plants from improved varieties showed a relatively higher degree of homozygosity for those dominant genes which give favourable expression.

THE RELATIONSHIP BETWEEN NUMBER OF BASIC PLANTS IN *L. perenne* VARIETIES AND THEIR FINAL PERFORMANCE (E.L.B. AND E.J.L.)

This is an extension of the experiment discussed in the preceding section and involves the same basic material. Fifteen experimental varieties have been constructed based on from 2 to 7 plants and each variety was initially multiplied in isolation for seed through four generations (P.B.V.). The varieties of each generation have been planted out in the field as spaced plants and as broadcast plots both arranged in a randomised block layout. Despite inclement weather the plants are well established and data should be available in 1959.

THE BREEDING SYSTEM IN *Phleum* (A.R.B. AND D.E.S.)

In the Report for 1950–56 seed setting data were presented to show the self-compatibility of plants of *Phleum pratense* (hexaploid), and *P. nodosum* (diploid). The germination results for the hexaploids have been completed and are summarised : 78% of the non-inbred (I_0) on selfing produced caryopses with their own pollen, and in the I_1 and I_2 plants 53% and 29% respectively. Of these caryopses 12% were inviable and derived mainly from plants of very low self-compatibility.

The germination data show that I_0, I_1 and I_2 plants gave only normal greens in 56%, 32% and 22% respectively of the number tested. In the remainder the most common seedling mutants were non-surviving greens and albinos ; 28% were heterozygous for two recessives.

In 1958 selfing was restricted to selected plants of *P. nodosum* ($2n = 14$) and *P. pratense* ($2n = 42$). Limited amounts of seed are available for I_3 and I_4 generations. The data from these together with those obtained in previous years will be utilized to investigate the control of self- and cross-compatibility, and also to provide information on the general decline or increase in vigour associated with these breeding systems.

GENECOLOGICAL STUDIES. AUTECOLOGY : *Phalaris arundinacea* (P.B.V.). Work has continued on the problem of dormancy and delayed germination in reed canary grass. A periodicity has been found in dormancy, in that seed sown within a week or two

of harvesting germinated 95% or better, but fell steeply when tested in October or November. By the following spring germination had risen almost to the immediate post-harvest figure, but during the summer dropped again to a very low level. This cycle was repeated in the first post-harvest year, and in one case the germination in the second spring, 18 months after harvest, was better than in the first, possibly this finding might give a lead to a means of improving germination on a field scale.

The basic cause of delayed germination appears to be a water-soluble inhibitor present in the caryopsis. Pricking or scarifying the seed apparently results in an improved O_2/Co_2 balance setting in motion an oxidative mechanism which removes the inhibitory effect.

The normal method of maintaining plants by cloning in the autumn and re-potting was not satisfactory with *P. arundinacea,* the plants formed only a few poor inflorescences and were in no way comparable to those produced under field conditions. An attempt to overcome this difficulty has been made by putting the plants out in the field to overwinter and re-potting portions at ear emergence in the early summer.

The individual progenies from the diallel cross of the basic plants in the experimental variety Bs 2480, show that there is little variability between the progenies ; they do, however, show a response to selection, and follow the parental type in density of growth and breadth of leaf.

A polycross was carried out in 1957 between 18 plants of pronounced creeping habit, and the progenies are now out in the field for observation. These plants are of a type quite distinct from Bs 2480, and the two lines should provide an interesting comparison between the extreme growth habits of reed canary grass.

Arrhenatherum elatius. Commencing in June 1957, Mr. C. D. C. Pfitzenmeyer, a British Council Scholar, made a survey of the variation in growth form, morphological characters, and date of panicle emergence in seedlings and adult plants, both indigenous and imported. Floral biology and self-fertility and the effect of photoperiod on head production were investigated.

A beginning was made on the study of the distribution of the species in Britain in relation to ecological factors.

Molinia caerulea and *Alopecurus* spp. (E.J.L.). Studies in these species are continuing.

CYTOTAXONOMY :

Holcus (A.R.B.). During 1957 triploid hybrids of *H. lanatus*, $2n = 14 \times$ *H. mollis* $2n = 28$ were back-crossed to both parents by hand-pollination. It will be of interest should pentaploid, $2n = 35$, seedlings be obtained, since this is the form of *H. mollis* most commonly found in nature. Parallel tests were carried out under conditions of open pollination by placing clones of the triploid (a) in a field where *H. lanatus* ($2n = 14$) was abundant, (b) interspaced with plants of tetraploid *H. mollis* in a greenhouse, and (c) in a young woodland where *H. mollis* of unknown chromosome number was abundant.

Dactylis (M.B.). The survey of collections of wild *Dactylis* has continued. Diploid and tetraploid ecotypes of agronomic and genetical interest have been found, including the following :

Dactylis maritima, tetraploid, a hardy, winter-green maritime species characterised by soft foliage of a distinct epidermal type, and prostrate, densely-tillering habit.

D. glomerata ssp. *lusitanica*, diploid, from Portugal, which is large-growing, vigorous, and winter green.

The interfertility of seven different diploid subspecies has been studied, and the relation between the three main tetraploid groups, *D. maritima*, *D. glomerata* ssp. *glomerata*, and *D. glomerata* ssp. *hispanica*. The results obtained suggest that the taxa with the same chromosome number are interfertile.

The progenies obtained between triploids used as female, and diploid or tetraploid male parents, include a proportion of fertile hybrids with 14 or 28 chromosomes. This provides a means of recombining the genomes of diploid and tetraploid races.

A study has been made of epidermal type in *Dactylis*, particularly of *D. maritima* and its allies. The results show that the inheritance of epidermal cell type is under polygenic control. The results of the morphological survey of the genus reveal the value of an experimental approach in assessing the reliability of characters used by the taxonomist. In *Dactylis*, over the broad range of diploid and tetraploid populations, the lemma apex conformation, usually regarded as a good taxonomic character, is negatively correlated with panicle size, and shows a cline of variation related to environment. A further experiment has been started to test the effect on lemma apex of deliberate selection for long and short panicles.

Anthoxanthum (M.B.). The collection of diploids has been extended and the cytologist has studied their somatic chromosome morphology, and meiotic pairing. The results indicate that the basic

wild forms can be distinguished by the number and type of satellite chromosomes present; further progress will necessitate collections from wild Mediterranean populations.

The self- and inter-fertility of the species *A. alpinum*, diploid perennial ($2n = 10$), *A. puelii*, diploid annual ($2n = 10$), and *A. odoratum*, tetraploid perennial ($2n = 20$) have been studied. Hybrids with *A. alpinum* were difficult to obtain, but the other species crossed freely. The triploid hybrids of *A. puelii* × *A. odoratum* have a strong resemblance to the female parent irrespective of the direction of the cross. The self-fertility of all 3 species was low. The polyploid *A. amarum*, $2n = 80$, was examined and found to be self-fertile. The most successful hybridization was obtained when the inflorescences were not enclosed, but the plants isolated in positions giving protection from contaminant pollen.

Seeds of annual *A. puelii* and perennial *A. alpinum* have been colchicine-treated with the object of producing synthetic autotetraploids for comparison with the wild tetraploid *A. odoratum*. Chromosome counts show that some of the treated plants have tetraploid ($2n = 20$) roots, and a few of the heads so far examined show the tetraploid number of chromosomes at meiosis.

Fertile tetraploids have been produced from the sterile primary hybrid between *A. alpinum* and *A. puelii*. When fully studied cytologically these will be compared with other synthetic polyploids, and wild tetraploid *A. odoratum*.

Intergeneric and interspecific hybrids, and their derivatives as sources of new breeding material (P.B.V.)

Investigations into the agronomic potentiality of *L. perenne* × *L. italicum* hybrids (see 1950–56 Report) were continued. Additional families were grown in 1956 and the results have generally confirmed the findings of the first phase of the experiment. Some of the selfed progenies deriving from these crosses were remarkable for their uniformity and comparative vigour and a number showed characteristics of possible agronomic value. It is noteworthy, however, that only a relatively small proportion gave progeny of potential value greater than, or equal to, those from intra-varietal crosses.

Further studies confirm the earlier findings that the viability of seed from these interspecific crosses is, in general, greater when *L. italicum* is the female parent.

The four intergeneric hybrids possible between *Lolium multiflorum*, $2n = 14$, *L. perenne*, $2n = 14$, *Festuca pratensis*, $2n = 14$,

and *F. arundinacea*, $2n = 42$ have been made (E.J.L.). There are certain main features which are common to all, namely, that within each species there are certain genotypes which will cross more readily with those of the opposite genus; there are reciprocal differences in crossability, and all F_1 hybrids are sterile.

From an agricultural point of view it would appear that crosses involving *L. multiflorum* give more promising potential breeding material than those with *L. perenne* as one parent.

L. multiflorum × *F. arundinacea.* Five F_1 families of this cross were available and 24 superior phenotypes were selected for treatment with colchicine in an attempt to restore fertility by doubling the chromosome number, which was $2n = 28$. Each plant was broken down into ten tillers and treated by the usual method of injecting and capping. Approximately 25% of these died as a result of the treatment, but of the remainder 12 clonal units produced from 1 to 3 male fertile inflorescences. Pollen examination showed that dehiscent anthers always had more than 40% stainable pollen.

Fertile inflorescences were isolated and intercrossed and caryopses obtained, those that were classified as heavy germinated and developed into reasonably vigorous plants. Chromosome counts confirmed that all fertile tillers were $2n = 56$. Inflorescences have been fixed for cytological examination.

L. multiflorum × *F. pratensis.* Selected plants from S.22 Italian ryegrass and S.215 meadow fescue were intercrossed successfully. Seed setting was higher when Italian ryegrass was used as female and in four *L. multiflorum* genotypes it was very high in all crosses attempted.

Some families have been found to be consistently vigorous under single plant conditions and this has been traced to the maternal effect of two *L. multiflorum* genotypes. A number of plants have been selected for treatment with colchicine.

L. perenne × *F. pratensis.* The fertility of colchicine-treated hybrids from this cross proved disappointing on the basis of anther dehiscence. This was accentuated as a large proportion of the treated plants produced no inflorescences and only a few developed in the remainder. This will be repeated.

L. perenne × *F. arundinacea.* A number of F_1 hybrids have been selected for treatment with colchicine. Chromosome counts confirmed the expected number of $2n = 28$.

Biochemical, physiological and phenological studies

Coumarin in sweet vernal grass

As part of an investigation into the utilization of sweet vernal (*Anthoxanthum odoratum*) for marginal hill areas, an assessment of the coumarin content was undertaken by Dr. W. M. Ashton and Mr. E. Jones, Department of Agricultural Chemistry, U.C.W. They were able to evolve a technique for rapid and accurate quantitative assessment for small samples and found that although absent in the seeds coumarin was present in small quantities in the root and shoot of very young seedlings. The quantity increased with the growth of the plant, diminished as the leaves matured, and disappeared as they died. In the inflorescences the coumarin increased up to the flowering stage and then diminished. There were plant-to-plant differences in coumarin content so that selection is possible should the need for it arise. The evidence suggests that the situation in *Anthoxanthum* is different from that in *Melilotus* in that the coumarin does not make the grass unpalatable.

Sweet vernal grass hay artificially spoilt contained traces of dicumarol.

The physiology of non-flowering varieties of herbage grasses (P.B.V.)

It may be technically possible to develop varieties of herbage grasses which will remain vegetative in the area to which they are agronomically adapted. Seed production of these varieties might be carried out in other areas, which by reason of their temperature and daylength would be conducive to flower formation.

In collaboration with Dr. M. L. Peterson, University of California, a study was undertaken to obtain basic information on the yield and composition of non-flowering ryegrass compared with normal flowering plants. It might be expected that non-flowering strains would show a smoother growth curve, and have a lower fibre percentage and a higher protein content than flowering strains grown under the same conditions. The results were inconclusive and further work is necessary. Nevertheless, the data indicated that the non-flowering plants had lower fibre content than those which flowered and also greater shoot weight during the developmental period, although there was a tendency for the latter trend to be reversed at flowering. The reversal was most marked in Irish ryegrass, where the flowering stems form a major part of the shoot weight. In the leafy varieties, where the stems represent a

small proportion of the total shoot yield, a complete reversal does not appear to take place.

Leaf morphology in various *Gramineae* (M.B.)

Studies on the developmental effects of inflorescence initiation on leaves of the main shoot are being continued using the self-fertile annual species *Lolium temulentum* and *Triticum vulgare* (variety Squarehead's Master). Particular attention is being devoted to cell size and number in the epidermis, and to the relative proportions of leaf blade and sheath.

The effect of altitude and exposure on inflorescence emergence (A.R.B. and D.E.S.)

The study of the reaction of clones of different genotypes growing at a range of altitudes has now reached its final phase. The data obtained confirm previous findings that heading and anthesis dates are delayed as the altitude increased, but exposure also has a marked influence on the end result.

Meteorological conditions and their relation to anthesis and growth (A.R.B. and T.E.)

Studies on anthesis were continued and extended in 1957 to include *Phleum* as well as *Lolium*. Timothy differed from ryegrass in that the threshold requirements for temperature and light were lower and degree of humidity was non-critical. The temperature at which timothy will start to exsert anthers and stigmas is to some extent conditioned by that prevailing during the previous afternoon and early evening.

During 1958 the investigation was again extended to include *Alopecurus pratensis, Festuca arundinacea, F. pratensis, F. ovina* and *Dactylis glomerata*. Each species was found to have its own optimal requirements for temperature and light. This applied within narrower limits to varieties within species.

Data have been collected on leaf and tiller appearance and size. These indicate that species occupy different sections of the general range of requirements for light and temperature.

PLANT GENETICS (GRASSES)

J. P. Cooper

The main research project continues to be the study of those genetic and physiological differences between species and varieties which are responsible for their variation in field performance. Most of the work has been concerned with the genetic control of inflorescence development, its heritability and response to selection, but attention is now being given to leaf and tiller development, particularly under competitive conditions.

Screening for flowering responses

Lolium (*short-day induction*). Previous studies suggested that short-day might have an inductive effect on floral development, either alone or in combination with low temperature. In autumn 1956, therefore, a number of *Lolium* populations were independently tested for response to short-day and low temperature induction. Both the short-day and low temperature induction *alone* revealed the same grouping of varieties, with no requirement in the summer-annual Westernwolths, a quantitative response in the winter-annual Wimmera, and an absolute requirement for cold or short-day in most of the perennial varieties. The greatest requirement was shown by the extreme pasture varieties, Kent, S.101 and S.23.

A further survey was made in spring 1957 of the inductive requirements of a range of ryegrass populations including Westernwolths, Wimmera, and Italian ryegrass, Irish, New Zealand, Kent, S.24 and S.23 perennial ryegrass. The induction treatments included *low temperature alone* (0–4°C.), *short-day alone* (8 hr.), and *low temperature and short-day concurrently*. Low temperature and short-day given concurrently had the same inductive effect as low temperature alone. The response to short-day or low temperature induction *alone* was similar to that encountered earlier; Westernwolths showed no requirement and Wimmera a quantitative response, while in the perennial varieties, S.23 and S.24 showed the greatest requirement, and Irish and New Zealand the least. Considerable genetic variation in response occurred within each outbreeding population. Both short-day and low temperature induction may, therefore, be important under field conditions.

Lolium (*Mediterranean ecotypes*). A number of Mediterranean ecotypes of *L. perenne* and *L. rigidum* obtained by courtesy of Mr. C. Rossetti, F.A.O, Rome, were tested for response to low temperature induction.

Most of the samples of *L. rigidum* headed rapidly under all treatments and showed little response to low temperature. The samples of *L. perenne* headed less rapidly than the *L. rigidum*, and many plants showed a qualitative requirement for low temperature, although in all samples more than 50% of the seedlings headed without cold treatment. Great variation in response was apparent within each sample.

In their response to low temperature induction, these ecotypes of *L. perenne* are intermediate between the Mediterranean samples of *L. rigidum*, and the North European types of *L. perenne* in which less than 10% of the plants form heads without low temperature.

Lolium (*photoperiod requirement*). Seedling material was given complete induction either by cold or short-day, and then transferred to a 10 hr. photoperiod. This was increased by ½ hour each week, corresponding to the gradual lengthening of natural photoperiods in the spring.

Early (Wimmera, Irish, New Zealand), medium (Italian) and late (Kent, S.23) groups of ryegrass can be rapidly distinguished in this way and it is planned to extend the tests to a wider range of material.

Phleum. In earlier work, a wide range of timothy varieties proved to have no winter requirement for either short-day or low temperature, and to be long-day in their photoperiodic requirements. Nevertheless, many seedlings failed to head when grown in continuous light in a warm greenhouse, but instead formed long indeterminate shoots or stolons.

Further work suggested that the comparatively high greenhouse temperature (mean $>$ 60°F.) prevented heading in some seedlings of most varieties, even though photoperiod was adequate, and this inhibitory effect of high temperature was confirmed by growing seedlings in natural long days at greenhouse and outdoor temperatures. The degree of tolerance to high temperature in the hexaploid varieties could be related to the May temperatures of their region of origin, the American and Canadian varieties being the most tolerant, and the Scandinavian, particularly the Finnish material, the least.

Dactylis. Although most varieties of *Dactylis glomerata* appear to have a winter requirement before heading in the field, it has still not been possible to satisfy this requirement artificially, either by short-day or low temperature *alone*, or by short-day *preceding*, *during* or *following* low temperature.

Genetic control of flowering responses

Date of ear emergence. The heritability of date of ear emergence in ryegrass after an autumn sowing has been assessed in two ways, firstly, from an analysis of variance of clonal material, replicated within and between years, secondly, by the use of parent/progeny regression in the same year. The latter method measures only the *additive* portion of the genetic variation.

Analysis of clonal material within each year gives estimates of more than 0.9 for both Irish and Kent ryegrasses. Correlations of clonal performance between years give figures of over 0.8, although the absolute date of ear emergence for a particular clone may vary by more than a week between an early and a late year. The data from single crosses and selfings of Irish and Kent ryegrass provide estimates of heritability of more than 0.8 in all three years, indicating that most of the variation is additive. Pronounced inbreeding depression occurs for this character.

Winter requirement. The winter requirement before heading was tested in the original Irish and Kent populations, and first and second generation progenies derived from them, firstly, by the extent of heading after a spring sowing outdoors ; secondly, by the heading behaviour in the greenhouse after artificial low temperature and short-day induction.

A high correlation was obtained between the field and greenhouse methods of assessment, and also between the field results from a March sowing in 1955 and a February sowing in 1957. Appreciable changes in the extent of winter requirement have occurred as a result of two generations of selection.

Genetical structure of ryegrass populations

Response to selection. Response to selection for ear emergence in Irish and Kent ryegrass continued in most lines in 1957 and 1958, but to a lesser extent than in previous generations.

The *means* of the extreme lines are now well outside the ranges of the original populations (see Table). The response shows pronounced assymetry, the advance towards earliness being less than that towards lateness. In both varieties the variation released from within four plants of the same emergence date is much greater than that expressed phenotypically in the original population, and by the fourth generation, the full range of Irish has been obtained from Kent, and of Kent from Irish. The two populations evidently share much of a common gene pool.

The lines still contain appreciable genetic variation, and there has been no apparent decrease in vigour.

Response to selection for ear emergence, 1958.

	Irish				*Kent*			
Original population								
Mean	7.5 May				29.7 May			
Variance	23.2				16.7			
Range	29 April–19 May (20 days)				19 May–6 June (18 days)			
Fourth generation								
Mean	27.1 A	23.5 M	9.8 M	1.9 J	5.2 M	6.2 J	29.9M	28.0 J
Var.	12.1	33.3	12.1	7.8	13.2	25.1	13.7	44.9
Range	21A–4M (41 days)	11M–1J	6M–19M (38 days)	27M–7J	25A–14M (53 days)	31M–17J	22M–7J (53 days)	12J–14 Jly
	Early/early	Early/late	Late/early	Late/late	Early/early	Early/late	Late/early	Late/late

Selection was continued in summer 1958, but both male and female sterility has appeared in two lines as a correlated response.

Correlated responses. Several ear characters were measured in 1957 in the above selection experiment to assess their heritability and to detect any correlated response to selection for ear emergence.

Significant differences between Irish and Kent were obtained only for length of ear and number of spikelets (Kent > Irish) and for number of florets (Irish > Kent). Considerable genetic variation occurred within varieties for all characters. The following estimates of heritability were obtained from parent/progeny correlations in 1957 :

Length of culm	+0.475	Length of spikelet	−0.090
Length of ear	+0.710	Length of empty glume	+0.846
Number of spikelets	+0.867	Number of florets	−0.129

Nearly all characters, except for length of the empty glume, showed pronounced inbreeding depression on selfing. The most stable character was length of the empty glume which did not fluctuate from year to year, and showed a heritability of more than 0.8 in all estimates.

Selection for late heading tended to increase the spikelet number, and to decrease the length of the empty glume, length of spikelet and number of florets.

Stability of S.23 during seed multiplication. The extent of genetic shift during seed multiplication has been studied in several sequences of multiplication of S.23 using Irish, Kent and Hunsballe for comparison. The characters recorded were (a) date of ear emergence after overwintering, (b) winter requirement before heading, and (c) leaf size, rate of leaf appearance, rate of tillering and dry weight in the seedling stage.

A slight advance in date of ear emergence of about 6 days occurred in two sequences of multiplication, but even the 6th generation stocks remained distinct from Kent and Hunsballe. No changes could be detected in winter requirement or in early seedling growth, but S.23 could readily be distinguished from Irish, Kent and Hunsballe.

Ample genetic variation for all the characters measured existed in the S.23 stocks, but this did not inevitably lead to genetic shift during seed multiplication.

Non-flowering varieties of ryegrass

The development and testing of non-flowering material of perennial ryegrass is being actively pursued in co-operation with Dr. M. L. Peterson, University of California, and Mr. P. B. Vose of this Station. Such material should show more uniform production through the summer than flowering plants and also retain a higher digestibility. Vigorous non-flowering plants have now been obtained in the third generation of selection for lateness from S.23 perennial ryegrass. These will be multiplied clonally for plot testing and chemical analysis.

Another suggested source of non-heading material has been populations from more northerly latitudes. Seed was collected from Lerwick, Shetland (60°N.), and also sent from Stavanger, Norway (59°N.) through the kindness of Mr. Magnus Jetne, but the seedlings from both these sources proved to be no later in ear emergence than S.23.

The production of seed from these non-flowering clones, either by the use of extended artificial light or by growing at more northerly latitudes, is now under study. The combination of the non-flowering character with other desirable agronomic features has also been started.

Leaf and tiller development

In the past two years more attention has been given to leaf and tiller development, its genetic control and relation to seasonal production under competitive conditions. The eventual aim is to see whether it is possible to select more effectively for sward conditions through a knowledge of the components affecting production in the sward.

Techniques of measurement

The establishment of standard techniques of measurement was started in autumn 1957, using seedlings of Italian ryegrass and of Irish and Hunsballe perennial ryegrass.

The net assimilation rates of the three varieties during the autumn were very similar, and differences in dry weight were attributable mainly to differences in total leaf area. Regular differences between these varieties occurred in leaf size and rate of leaf appearance, and considerable additive genetic variation for these characters existed within each variety. Large differences in fibre content between genotypes have also been detected.

Measuring total leaf area per seedling or per tiller is rather laborious and shorter methods are desirable for handling large amounts of material. The dimensions of successive leaves on the same tiller are highly correlated, as are the dimensions and rates of appearance of corresponding leaves on different tillers of the same plant. The size of the third and sixth leaf on the main shoot, and the time interval between them may thus be useful measures of the increase in leaf area per tiller during early seedling growth.

Simulated sward studies

A technique has been developed for comparing varieties or genotypes in a simulated sward under controlled competition and defoliation. Irish, S.24, Kent, Hunsballe and S.23 perennial ryegrass were sown in April 1958, at 2½" spacing. Leaf area, rate of leaf appearance and rate of tillering were recorded for each seedling and four cuts were taken during 1958.

Regular differences between varieties occurred for many of the seedling measurements, and for dry weight, tiller number and dry weight/tiller in the first cut. In subsequent cuts, however, none could be detected *between* the varieties, although considerable variation occurred *within* each variety. Differences between ryegrass varieties in seasonal productivity and persistency are closely related to the time and extent of heading, and greater differences between varieties would be expected in the first harvest year.

There was no correlation between the initial rate of tillering before competition began and the final tiller number attained, nor was the capacity for recovery correlated with the amount of undisturbed growth in the first cut. There is already a tendency for the large plants to become larger after successive cuts, and for the small plants to become smaller or die out. Further cuts will be taken next spring and summer to measure differences in seasonal productivity and it should then be possible to select and progeny-test parents for any particular curve of seasonal production.

LEGUME BREEDING

W. Ellis Davies

The 1956–57 winter was not severe, and there was practically no winter killing in the breeding nurseries, even plants of white clover from Mediterranean countries survived with little damage. Growing conditions during 1957 were generally favourable, apart from occasional drought which was particularly noticeable on one of the experimental areas.

In 1957–58 winter killing in the lowland centre was practically nil, but there was a considerable amount in the upland centre. Summer 1958 was poor for clover seed production (reminding us once again of the uncertainty of being able to harvest clover seed in the U.K.), the continuous rain encouraged vegetative growth and made conditions very poor for bee pollination and impossible for harvesting. Transplanting was, however, facilitated but the excessive growth of unsown grass made cleaning operations very tedious on the spaced plant area.

An outstanding feature of the year was the alarming increase in virus diseases in the clover breeding nurseries. The clover phyllody virus has been present for many years, but during 1957 and 1958 it assumed major proportions. There is also another condition, provisionally named "red leaf," the effect of which on plant vigour is very marked, and sometimes lethal.

Economic breeding

White clover (W.E.D.). The aim of this project, started in 1949, is to produce a new large-leaved, tall-growing variety of the Ladino type. Third generation families of Ladino × S.100 are now under study, and the first plot trial with this material was established in 1956. Comparisons were made between spaced plants and the behaviour of the same families when oversown with a companion ryegrass. An analysis of the first year data has shown that while some characters, e.g., leaf length, give a good correlation between spaced plants and plots, for other characters, e.g., yield, the results obtained are not in the same order. Further studies are, therefore, necessary before a final evaluation can be made.

The overwintering (1957–58) of the white clovers, S.100, Kersey and selections in the 1956 trial, was exceedingly poor and all the spaced plants gave the same reaction. It had been previously noticed that there is often a tendency for the centre of a spaced plant

to die in the first winter, followed in the succeeding winter by the whole plant. This is thought to be due to disease but the causal organism has not yet been identified.

Some selections within Ladino have shown improvements in uniformity and yield compared with original material but they have been very susceptible to disease, especially virus.

Some Kersey × Ladino F_1 families were studied in 1957 as single plants, many were promising but there was a very high incidence of clover phyllody. This condition does not seriously impair the vigour of the plant, but it prevents seed setting so that there was little point in making selections among them.

Red clover (W.E.D.). The new selection of late-flowering red clover without leaf marks known as AA2 was included in agronomy trials established in 1957 together with selection Aa3305. Particular note will be taken of the persistency of these two selections. Crosses made in 1956 between peaked plants of late-flowering red clover were established in the field in 1957 and some showed excellent uniformity in type while others segregated for a more prostrate growth habit. Many of the plants were infected with virus. Further selections will be made of the most promising material and these will be bulked to produce seed for testing in agronomy trials.

Lucerne (W.E.D.). Observations were made for the second year on F_2 families of the cross Rhizoma × Du Puits, and also on open-pollinated progenies of material of French origin. There was a considerable amount of leaf spot (*Pseudopeziza medicaginis*) in the autumn, but some of the progenies appeared more resistant than others. *Pseudoplea trifolii* was also observed for the second year on some families resulting from the cross Rhizoma × S.205.

Selections made in the second generation Rhizoma × Du Puits families were crossed in the greenhouse. Further polycross progenies of plants of French origin were established in rows and additional data were collected from similar trials established in 1956 and 1957.

Autopolyploids (A.M.E.). Data were collected in 1957 on the behaviour of 15 tetraploid families of red clover, which ere polycross derivatives from an earlier field trial. Ten families were superior in green weight to the diploid control varieties S.123 and S.151, while only four were superior to the Swedish tetraploid control variety Weibull's Tetra. The latter showed poor tillering capacity and the best in this respect was S.123. Three of the families, however, were almost as good, and five were superior in tillering to S.151.

Data were collected in 1958 from the fifth field trial of spaced plants of red clover and the fourth trial of white clover. Of the twelve families of red clover, five were better than the control varieties diploid S.151 and S.123. The highest tiller number was in S.123 but two tetraploid families approached this figure.

Progress was also made in the white clover programme which consists mainly of chromosome-doubled S.100. Two out of 14 families were superior to S.100 (diploid) control, ten were equal and two inferior. One family was taller than the control plants, four were the same height, the overall range being 19.0–24.0 cm. Seed setting was only fair but five families approached S.100 (control) in this respect.

In the second year three out of 17 polyploid families of white clover gave a higher yield of green matter than S.100 control and seven were equal to it in height, the range being 19.4 to 27.3 cm. In the hill plots (750ft. elevation) two out of five families gave similar yields to S.100 and three were inferior.

The yield from the seed islands of polyploid red and white clovers was very poor due to the adverse weather conditions.

Families of octoploid lucerne were found to be inferior in vigour and yield when compared with Du Puits. Hexaploids are now being developed as they may be more promising.

Potentiality trials

White Clover (W.E.D.). A fairly extensive collection of white clover populations from Europe and other parts of the world was available on completion of a survey of the frequency of cyanogenetic glucoside (*Ac*) and enzyme (*Li*) genes. Part of this collection was established on the field in 1956 as spaced plants to study the potentialities of these populations as sources of breeding material. Large differences occurred between the various populations and many seemed quite promising. Some of the eastern Mediterranean types were exceptionally vigorous and robust, but their winter hardiness could not be assessed because of the relatively mild conditions which prevailed in 1956–57. Plants collected in North-west France were also good and many were remarkably uniform in type. The mean flowering date ranged from 29 April for an Indian population, to 11 June for a population from Leichtenstein collected at an altitude of 1,500 ft. The range of variation is shown by the following figures for two lots (data collected after flowering) :

Origin	Spread (cm)	Height of leaves (cm)	Leaflet Length (mm)	Leaflet Width (mm)	Green weight (gm)	Mean flowering date
Israel	86.6	17.3	27.8	22.8	634.5	3 May
Norway	62.1	6.1	11.4	10.0	96.6	25 ,,

Samples of white clover from Chile, Pretoria, Adelaide, Western Australia, Tasmania and Brazil, were studied as spaced plants and their differences in leaf size, height, leaf markings noted, but none showed promise of being useful breeding material. In addition three lots of Kersey white clover were examined, but none of the differences observed was significant.

Red Clover (W.E.D.). The following yields of dry matter were obtained in the first harvest year from a small trial of red clover varieties :

	Dry matter lb. per acre 1957	
Early types	*Red clover fraction*	*Total yield*
Broad red	8896	9654
Glamorgan broad red	8775	9811
Kenland	7975	9920
Wisconsin Synthetic	7218	9233
Penscott	6871	8406
S.151	6511	8982
L.S.D. 5%	1470	1406

Differences were quite marked when the yield of the red clover fraction was considered, but total yields, including volunteer species, showed smaller differences.

Visual observation of the second harvest year plots indicated the marked superiority of the three American varieties, Kenland, Penscott and especially Wisconsin Synthetic. The yield data for 1958 have not yet been analysed.

Lucerne (W.E.D.). Third harvest year data were obtained from a lucerne variety trial established in 1954. The plots affected with *Verticillium albo-atrum* were eliminated in the autumn of 1956 by burning with a flame gun and applying formaldehyde before and after digging out the plants. These plots were sown with Italian ryegrass in 1957 and no further symptoms were observed on any

plots. The trial contained many of the newer French varieties, but none gave a higher yield than the current varieties Du Puits, Ormelong and Socheville. The new varieties included Emeraude, Orchésienne, F.D.100 and Gamma. The highest mean yield, 8272 lb. per acre over the three years, was given by Ormelong, the lowest by Provence lucerne at 5203 lb. per acre. Three lots of Poitou-type, Marais de Luçon, Marais de Challans and Poitou were included, and the average yield of these was 10% less than the Flamande types.

First harvest year data from a trial established in 1957 were obtained; the yield of lucerne fraction for the nine varieties was as follows:

	Cuts (10 *lb. dry matter per acre*)			
	First	*Second*	*Third*	*Total*
Alfa	264	323	193	780
Du Puits	236	299	178	713
G.P.R. 1	213	305	176	694
Cardinal	185	299	170	654
AF1/MI/55	241	244	153	638
G.P.R. 2	190	276	143	609
Omega	119	226	168	513
Vernal	167	148	91	406
Provence	73	148	95	316
L.S.D. 5%	63.3	53.6	32.0	—

There was considerable ingression of unsown grass into the plots chiefly of *Agrostis tenuis*.

Lucerne agronomy (W.E.D.). The experiment on lucerne and lucerne/grass mixtures established in 1952 was ploughed after the second cut in July 1956. Rape was sown to measure the residual fertility followed by oats in 1957. The yields of the latter have not been analysed. Growth of rape in 1956 was not very vigorous but marked differences were noted between plots. Samples were harvested at the end of November 1956, with yields varying from 2.3 cwt. per acre for rape after timothy sown alone, to 9.1 cwt. for rape after Du Puits lucerne. In general the yields followed a similar pattern to those of the preceding lucerne/grass mixtures as is shown by the figures:

	Yield of dry matter	
	1953–55	1956
	Mean	*Rape*
	tons per acre	*cwt. per acre*
Du Puits lucerne	4.0	7.3
Grimm	3.1	6.9
Du Puits + grass	4.0	6.9
Grimm + grass	3.4	5.9
S.123 red clover + grass	3.3	4.1
Grass alone	2.1	3.3

The application of 7 cwt. per acre per annum of sulphate of ammonia to the preceding legume/grass mixtures had little effect on the subsequent rape crop; better results were obtained after a 2–2–3 cutting treatment than by 3 cuts in the two first years followed by two cuts in 1955.

A new experiment was laid down in 1956 to study the reaction of other companion grasses and the behaviour of a selection of lucerne AF1, based on Grimm, Hungarian White Seal and Provence. The yields for the first harvest year are shown below:

	Total yield dry matter lb. per acre	
	Du Puits	*AF1*
Lucerne alone	8,912	7,036
,, + 2 lb. S.215 fescue	10,384	8,501
,, + 2 lb. S.37 cocksfoot	8,153	7,187
,, + 2 lb. S.22 Italian ryegrass	7,297	6,731
5% L.S.D.	978	

Grass growth was extremely vigorous in the seeding year and in plots sown without grass, bent quickly became established, AF1 being slow growing suffered more than Du Puits from ingress of unsown spp. Meadow fescue again proved to be the best companion and the plots looked green and vigorous; those with cocksfoot and Italian ryegrass, on the other hand, looked very yellow and the stand of lucerne was much thinner. Some of the lucerne seedlings in the Italian ryegrass plots made no progress after having reached a height of 3″–4″ in the seeding year, and remained in this state throughout the first harvest year.

TECHNIQUE STUDIES

A.194. *Lucerne*: *spacing of single plants* (W.E.D.). Because an earlier experiment showed that the interaction strain × spacing was significant, the present experiment was designed in 1956, to give information on plant spacings which would give results comparable to the broadcast plot. Four varieties of lucerne were compared as single plants, spaced 2′ × 1′ 6″, 1′ × 1′, 6″ × 6″, 3″ × 3″ and broadcast (control). A preliminary analysis of variance of the first harvest year data did not show a significant variety × spacing interaction, and the same trends appeared as had been noticed earlier.

	Yield of dry matter (lb. per acre)	
	Plants spaced 2′ × 1′6″	*Broadcast*
Du Puits	3,043 (100)	10,371 (100)
AF1	3,585 (117)	9,153 (88)
Provence	2,265 (74)	8,585 (83)

Under single plant conditions AF1 gave a 17% higher yield than Du Puits, but in the broadcast plots AF1 was 12% inferior.

A.200. *Tynpynfarch* (W.E.D.). Recently facilities have been made available to study breeding material under semi-upland conditions at an altitude of 750ft., 6 miles inland from the Headquarters of the Station. Before launching on full-scale screening of breeding material it is essential to have information on the extent of the differences likely to be encountered; accordingly a three-year pilot experiment was commenced in 1955 when a cross-section of seven varieties of lucerne, red and white clovers was established at upland and lowland centres. Spaced plants only of white clover were used but there were drills and spaced plants of the other two legumes.

Observations were made concurrently at both centres, but cutting has generally been done at the same stage of development. Flowering of the early varieties was retarded by 10–20 days in the upland centre, so that on some occasions it was possible to cut all varieties on the same date.

The outstanding difference between the two centres in 1955/56 and 1957/58 was differential winter killing. In the exceptionally mild winter of 1956/57 there was no winter killing in either centre: in the upland area in both 1955/56 and 1957/58 the least adapted

varieties suffered winter killing in varying degrees of severity, while at the lowland centre there was practically no winter killing of any of the varieties. These differences are illustrated by the following figures, showing percentage winter killing of lucerne for three years.

	Lowland centre			*Upland centre*			
Lucerne	1955/56	1956/7	1957/8	1955/6	1956/7	1957/8 †	1957/8††
		Per cent.				*Per cent.*	
Viking	3	1	1	20	3	18	13
Grimm	3	3	0	18	3	9	24
S.205	4	3	0	21	5	19	26
Du Puits	1	0	0	45	4	23	70
Chartainvilliers	8	0	0	48	3	21	74
Poitou	3	0	1	54	1	25	76
Provence	14	0	0	83	1	10	78

†planted 1956 (second winter)
††planted 1957 (first winter)

In the winter of 1957/58 plots established in 1956 and 1957 were compared. It will be seen that plants in their second winter showed much less winter killing than those in their first, probably due to differences in root reserves. Provence, as one expected, was the most susceptible variety but the other varieties of French origin also showed high mortality figures while the three lucernes of the Grimm type were considerably hardier.

Winter hardiness has been the major factor in causing interactions for yield at the two centres and it has not been possible to isolate the effect of winter killing from differences due to summer environment. Even where the plants have not been killed they have been so much weakened that their yield is very poor.

The complete results have not yet been analysed but the following figures illustrate the extent of the differences observed, relative yields of S.100 lowland = 100 of surviving spaced plants of white clover :

	1957		1958	
	Lowland	*Upland*	*Lowland*	*Upland*
S.100	100	61	100	25
S.188	80	42	67	25
S.184	84	34	83	22
New Zealand C.M.	99	41	74	19
Kersey	79	49	76	20
Dutch	124	27	55	11
Ladino	82	12	37	2
Mean	100	42	100	25

The mean yield at the lowland centre was the same for the two years, but in 1957 after a mild winter the mean yield at the upland centre was 42% of the lowland centre, and in 1958, after a severe winter, only 25%. The variety × centre interaction for 1957 was highly significant indicating that the varieties did not give the same relative yield at both centres, but in 1958 it did not quite reach the required level of significance.

It appears that the main value of the upland area will be as a centre for the preliminary screening of new material for winter hardiness. Genotypes with a long growing season are very important in the breeding programme and these invariably come from lower latitudes ; poor winter hardiness is often associated with this character so that efficient screening is important in the early stages of assessment.

GENETICAL STUDIES

Work on the genetics of the V leaf marks in white clover was continued. Combinations of all the alleles at present available were produced, viz: V^l, V^h, V^f, V^{ba}, V^b, V^{by}, V^p, and in most instances the heterozygotes could be readily identified. Where the marks were close together on the leaf, or in the same position, some difficulty was experienced, particularly in the young growth stage. The V^{by} parent was partially dominant over all the other marks. Homozygous lines of the above marks are being produced so that they can be incorporated in breeding lines.

The inheritance of anthocyanin was also studied, but classification was difficult because the appearance of anthocyanin pigment in some lines is dependent on low temperature, which outdoors is experienced only in early spring. This applies especially to the R^b (blotch) marking which is often associated with V^{by} leaf mark. At normal greenhouse temperature the expression of this allele is very variable. New material of the R^m allele was obtained from South Africa where a population contained 25% of this type ; and from Dr. King of the Hill Farming Research Organisation an all-red leaf R^l was received.

Lucerne (W.E.D., M.M.H.). The inheritance of flower colour was studied in many crosses involving violet, white and yellow flowers. The parent plants represented lines from Ranger, Lucerne A, Grimm, Poitou, Rhizoma, Du Puits, Ladak and *Medicago falcata* ($2n = 32$). The cross white × white gave only white flowered plants in the F_1 and F_2, and violet × violet gave only violet in F_1 and F_2.

Flower colour was controlled by factors which were tetrasomically inherited and the magnitude of α was near to 0, i.e., the gene in question was close to the centromere. Segregation in the cross yellow × violet was governed by complementary factors. In the other crosses it was inferred that one gene was responsible for the ratios obtained.

The inheritance of four seedling abnormalities was also studied. Chlorophyll deficiency was determined by a single gene inherited tetrasomically, and spotted leaves by two complementary factors with $\alpha = 0$. Selection for more than one cotyledon and also for two simple leaves increased the frequency of these types which appeared to be controlled by several genes.

Delphinidin, cyanidin, malvidin and kaempferol were detected in the flowers of the violet parents by using a paper chromatography technique. Delphinidin, cyanidin and quercetin were found in the green flowers of the F_1 hybrid between *M. falcata* ($2n = 16$) × Poitou; white-flowered Ladak contained quercetin, kaempferol and tricin, while in the yellow-flowered *M. falcata* ($2n = 32$) myricetin was also found. The segregation of malvidin in F_1 and F_2 was difficult to interpret because of the assumed influence of physiological and environmental factors.

Despite reports in the literature of disomic and tetra-disomic inheritance in lucerne it is considered that the evidence obtained is overwhelmingly in favour of tetrasomic inheritance and this suggests an autotetraploid origin for this plant.

Autopolyploidy (A.M.E.)

Autopolyploids are generally regarded as being more self-compatible than the original diploids and this was tested in the material under investigation. In 1957 it was found that 11 out of 25 polyploid white clover plants were incompatible; when 200 florets per plant were selfed there was no seed. Self-compatibility of the other plants was low, ranging from 0.5 to 3.5% with a mean of 1%. In red clover 400 florets were tripped on each of 15 polyploid plants and no seed was obtained from 6; seed set in the remainder varied from 0.25 to 20% with a mean of 2%. Lucerne polyploids gave a higher seed set on selfing 40 plants than the other two species, some plants giving up to 35% seed set.

In 1958 S_1 plants of polyploid lucerne, red and white clovers were selfed with the following results:

Species	No of plants selfed	Seed setting Nil	Seed setting Remainder	Per cent Range	Per cent Mean
White Clover	20	16	4	0.5– 4	0.6
Red clover	25	6	19	0.3–23	2.5
Lucerne	24	9	15	2.5–52	16.7

The clovers gave a similar result to that of their parents in 1957, while in lucerne S_1 plants seed setting was lower than in the parents.

Further chromosome-doubled plants without leaf marks were obtained from S.100 " Nomark " and S.123 " Nomark " red clover.

INTERSPECIFIC HYBRIDIZATION

Trifolium (A.M.E.). No new species hybrids were produced in 1957 and 1958 but further hybrids of two of the three species combinations previously obtained were produced by using different parental genotypes. These were diploid, tetraploid, hexaploid, *T. ambiguum* × *T. hybridum* and reciprocal, and *T. repens* × *T. nigrescens* and reciprocal. It was decided to investigate the genetics of *T. nigrescens* and *T. ambiguum* to aid in the understanding of hybrids involving these species. Very little work up to now has been done on the genetics of these species compared with those of greater agricultural importance such as *T. repens* and *T hybridum*.

Medicago (A.M.E.). The genus *Medicago* includes about 50 annual and perennial species some 25 of which have been tested as agricultural crops. Only the perennial species are likely to find a place in British agriculture and the following *Medicago* spp. are under study :

M. sativa (2x) ; *M. sativa* (4x) ; *M. falcata* (2x) ; *M. falcata* (4x) ; *M. gaetula* (2x) ; *M. hemicycla* (2x) ; *M. glutinosa* (4x) ; *M. coerulea* (2x) ; *M. platycarpa* and *M. media*.

Since the classification and distinguishing features of some of these are somewhat indefinite, detailed morphological and cytological studies are being made on 10 plants of each species. The characters noted are : habit, number of tillers and tiller length, number of nodes to flowering, leaf size, nature of stipules, flower colour, number of florets per head, self-fertility, chromosome number and morphology. There was considerable interspecific and some intraspecific variation ; a small number of plants of each species have now been planted in the field and data will be taken to record differences.

In the interspecific crosses, parents were chosen which had distinctive characters which could be recognised in the hybrid. Seed was obtained from the following crosses :

M. sativa (4x)	× *falcata* (4x)	+ reciprocal
,,	× *glutinosa*	+ reciprocal
,,	× *media*	
,, (2x)	× *coerulea*	
,,	× *hemicycla*	
M. falcata (2x)	× *hemicycla*	+ reciprocal
,,	× *coerulea*	+ ,,
,,	× *gaetula*	
M. hemicycla	× *gaetula*	
,,	× *coerulea*	+ reciprocal
M. gaetula	× *coerulea*	
M. glutinosa	× *media*	

Embryological studies are being carried out to ascertain why seed development is poor or does not occur in some species crosses.

VERNALIZATION AND TIME OF FLOWERING (W.E.D.)

Lucerne. In order to expedite the rapid turnover of generations it was desirable to know whether lucerne had a low temperature requirement before flowering occurred. Germinating seed was placed in a refrigerator for varying periods, planted out at the end of April, and the time from planting to first flowering noted. The experiment was repeated for two years. Low temperature treatment was given in 1956 extending to 14, 28, 42 and 56 days, and in 1957 to 7, 14, 21, 28 and 35 days, plus untreated controls. Lines from Ladak, Grimm, Du Puits and Provence were used in both years with Ranger and Altfrankische in 1956 and Rhizoma and Caliverde in 1957. None of the low temperature pre-treatments had any consistent effect and the mean number of days from planting to flowering of the control was 82 in 1956 and 75 in 1957. Differences between lines were highly significant; Ladak, one of the earliest, had a mean of 77 days and Grimm, the latest, 91 days.

Red clover. Germinating seed of red clover was similarly kept in the refrigerator for 15, 30, 45, 60 and 75 days before being sown, plus untreated control, and the plants were grown in three daylengths. The varieties in order of earliness were Broad red, S.151, English late-flowering, Montgomery and S.123.

The low temperature pre-treatment had no effect on the flowering of any of the varieties, which maintained the same order in the three daylengths, but there was a significant variety × length of photoperiod interaction ; early varieties responded more rapidly to increased daylength than the late.

Pathology

Dr. Carr, who had a Quincy Ward Boese Post-doctoral Fellowship, followed by a National Science Foundation Scholarship, both tenable at Columbia University, New York, returned to the Department on 1 July 1958, after leave of absence extending from September 1956, to June 1958 ; the main lines of work were at a standstill during this period.

An island of plants selected for resistance to clover rot (*Sclerotinia trifoliorum*) produced 3½ lb. seed in 1957. It is aimed to test this under field conditions during 1959.

Phyllody of white clover (W.E.D.)

During the last two years the severity of virus diseases has become a major problem in the clover nurseries. Clover phyllody has been present in small proportions for many years but only in 1957 did it become seriously limiting. The disease, which also affects strawberries, has been described by Frazier and Posnette[1]. They found the jassids could transmit the virus from clover to clover, as well as to and from a wide range of hosts. In the autumn of 1957 in conjunction with the Entomology and Pathology Department, N.A.A.S., Trawscoed, a pilot experiment was started to see if the leaf hoppers could be killed by spraying with 5% D.D.T.

In 1958 the treatments were continued, but had no effect on the frequency of plants showing symptoms. A new experiment was commenced in 1958 in which plants were sprayed from the time of planting and different spraying materials were used. Some of the treatments will continue into 1959 and the results will not be known until the next flowering season.

Broomrape control (W.E.D.)

An experiment designed to control broomrape in clover crops was completed in 1957, but none of the treatments was completely

[1] Frazier, N.W. and Posnette, A.F. 1957. Transmission and host-range studies of strawberry green-petal virus. *Ann. appl. Biol.* 45, 580-588.

effective. Mercurial seed dressings before sowing had no effect on broomrape counts in the following year; pre-treatment with one crop of linseed likewise did not decrease the amount, but two successive crops reduced the counts by half. In the preliminary analysis this difference was not significant, even if it had been there was still enough broomrape to give a heavy infection and it is anticipated that pre-treatment would have to continue for many years to get a substantial reduction in parasites. A detailed account of this experiment has been accepted for publication.

CEREAL, BEAN AND BRASSICAE BREEDING

D. J. Griffiths

THE CEREAL CROPS

Winter oat breeding (D.J.G., J.D.H., and I.J.)

The most notable event which occurred in winter oat breeding during the two-year period under review was the official recommendation of Selection V.1022 by the National Institute of Agricultural Botany in 1957. As a result, a first distribution of Foundation Seed of this new variety, named Penrhyn S.234, was made to Seed Firms and Seed Growers' Associations for autumn sowing 1958. This new variety, briefly described on page 76, was developed through repeated selection from amongst the progeny of a cross between S.147 and Station-selection 0379 made by E. T. Jones in 1938. It is a high yielding type with medium length straw intended for soils of moderate to good fertility. In 1958 the stem eelworm resistant winter oat selection W.271 developed for soils of medium to high fertility also completed its three years in primary trials with the N.I.A.B. and favourable reports were received on the general performance of the new mildew resistant selection 5370Cn 2/2/41 during its first year in preliminary trials.

One hundred and sixteen newly-developed selections were screened in the small scale yield trials and the results indicated that the ceiling yield performance in the winter oat crop has not yet been reached. As a result of the mild winters during both years, it was impossible to detect differences in winter hardiness amongst the winter oat progenies, a fact which again emphasises the need for an artificial technique to test segregates for cold resistance.

The analysis of results from various segregates in the breeding trials indicated that the greatest variation in yield lies between F_2 selections, with successively less variation within F_4 and F_6 derived lines. It is felt, however, that the technique of yield testing in early generations requires further investigation to enable the breeder to detect at an early stage the most promising material for intensive study and selection.

Through the co-operation of the National Institute of Agricultural Botany additional small plot yield trials involving 49 selections were conducted at Seale-Hayne Agricultural College, Devon,

and at Norfolk Agricultural Station, Sprowston. Although there was an interaction of variety with location a high proportion of the selections outyielded S.147, the control variety, in the three locations over the two years. It is planned to continue this investigation so that a valid estimate of within-location, location × variety, and variety × season interactions may be determined.

AGRONOMIC STUDIES WITH WINTER CEREALS (J.D.H.)

The effect of spring defoliation on the subsequent grain yield of Powys S.226 was investigated and for this purpose a factorial experiment was laid down involving cutting, grazing and application of nitrogen on various dates.

The yields of herbage (dry matter) and grain obtained after defoliation at various periods in the spring of both years were as follows:

Season		*Control* *No defoliation*	*Date of defoliation* *February*	*March*	*April*	*S.E.*
1956/7	Grain (cwt/acre)	31.5	31.1	27.8	15.5	±1.03
	Herbage (lb/acre) dry matter	—	594	1435	2510	
1957/8	Grain (cwt/acre)	28.1	25.6	25.2	22.8	±0.52
	Herbage (lb/acre) dry matter	—	330	590	1340	

Essentially similar results were obtained in both seasons. There was, however, more herbage available in the spring of 1957, but the ensuing reduction in grain yield after defoliation was also more marked.

The value of spring nitrogen on winter oats was emphasised, the overall effects on grain yield (cwt/acre) of applying 3 cwt. of nitrochalk at various dates may be seen from the following data:

		Nitrogen applied as *3 cwt. of nitrochalk in*			
Season	*Control* *No nitrogen*	*February*	*March*	*April*	*S.E.*
1956/7	22.1	26.0	26.1	31.7	±0.48
1957/8	18.1	26.7	28.0	29.0	±0.52

In addition 40 varieties of winter cereals were screened for their potentiality in providing spring grazing. The winter ryes, in particular those from Eastern Europe, proved outstanding in this respect.

SPRING OAT BREEDING (D.J.G., D.G.R., I.J., AND W.T.H.P.)

Observations made on the incidence of frit fly damage in the seedling stage revealed small relative differences in varietal reaction with Eagle, Sun II, Blenda and some Finnish types showing slightly fewer damaged tillers than the others per foot length of drill. The advantage of the thicker seeding over thin under incidence of high frit fly was clearly borne out in the observations made on a series of varieties sown at 3 seed rates, the results indicating a highly significant correlation coefficient of -0.549 for seedling population and number of shoots attacked, a feature which reflected a greater difference than that shown between the reactions of susceptible and the most resistant varieties. Severe damage was also caused to grain samples by the second generation of frit fly, and judging from frequent reports of disappointing spring oat grain yields received during the past few years, there is reason to believe that in certain localities crop losses arising from the ravages of second generation flies are even more severe than those caused by the first generation.

Selections derived from crosses involving Cc 4146 as the mildew-resistant parent maintained their superior resistance to mildew throughout the two seasons, but those derived from 01747/10/7, which in previous years had revealed satisfactory resistance under field conditions, succumbed to attack late in the 1957 season. Despite this, however, these latter types again proved their superiority over Sun II in respect of yielding ability and standing power. The relative mean yields of these selections compared with Sun II at three different locations were as follows :

Selection	*Parentage*	*Relative grain yield as percentage of Sun II*
5016/4/4/3	01747/10/7 × S.225	151
5025/9/1/14	,,	147
5020/19/5/63	,,	143
5026/3/44	,,	133
5027/36/2/1	,,	120

Favourable reports were received from the N.I.A.B. Regional Centres in the western parts of the country where oat mildew is most widespread on the performance of 4757/18/2/19 in respect of its resistance to both mildew and crown rust, and general yielding capacity as well as standing ability. The F_3 progenies of crosses made in 1955 between this selection and various stem eelworm resistant selections were studied critically with the purpose of isolating genotypes possessing resistance to mildew, crown rust and stem eelworm.

The work of searching for resistance to *Heterodera major* amongst diploid, tetraploid and hexaploid forms of *Avena* spp. was continued in collaboration with Mr. T. G. Davies, Advisory Entomologist, N.A.A.S. Bangor Sub-Centre. The results of pot experiments indicated that the most promising sources of resistance determined on the basis of cyst counts appear to be forms belonging to the wild hexaploid species *A. sterilis* and the tetraploid species *A. abyssinica*.

Further data were obtained confirming the successful control of halo blight, a seed-borne disease, through treatment of the seed with antibiotics prior to sowing. Screening tests for reaction to this bacterial disease revealed better resistance in the hexaploid Cc 4146 than in any form reported hitherto in the literature, and in consequence crosses were made between this form and susceptible varieties to study the mode of inheritance of resistance to the disease, and for the selection of resistant agronomically-desirable forms for further breeding work.

IRRADIATION STUDIES WITH *A. sterilis maxima* (D.J.G. AND T.D.J.)

Small numbers of the X_3, X_4 and X_5 generations of irradiated *A. sterilis maxima* were grown to obtain further information on the previously reported mutants. During the previous year it had been noted that in families segregating for the sterile fatuoid aberration a variation existed in size of grain of otherwise phenotypically normal plants. The non-fatuoid plants could be divided into plants with normal sized grain (c.34 mm. length of outer palea) and those with small grain (c. 29–30 mm.). In the 1957 experiments the small-grained plants gave rise to a proportion of sterile fatuoids in their offspring whereas the larger grained did not, thus indicating a deleterious effect of the aberration in the heterozygous state.

Cytological examination during 1958 revealed that the fertile fatuoids had 42 chromosomes with no obvious meiotic irregularity. The sterile fatuoids, on the other hand, proved to be 40 chromosome-types with plants heterozygous for the character giving counts of 41, indicating a situation analogous to the B-type fatuoids occurring as spontaneous mutants in cultivated oats

CYTOGENETICS OF *Avena* (D.J.G., D.G.R. AND W.T.H.P.)

Seeds were obtained from a few tillers of the triploid hybrid *A. abyssinica* × S.171 after colchicine treatment of the hybrid seedlings, and data taken on the morphology, fertility and pairing behaviour of the first generation plants of the derived 6*X* amphiploid form *A. abyssinica* × S.75. Some of these plants proved

superior in fertility and showed better pairing at meiosis than any amphiploid progenies hitherto studied.

The A_4 generation progenies of the 6*X* amphiploid from *A. abyssinica* × *A. brevis* showed poor adaptation to field conditions, giving rise to plants with a predominance of *A. abyssinica* growth characteristics and a seed set inferior to that obtained in the greenhouse.

All hybrids between the 6*X* triploids and the natural hexaploids produced to date have proved almost completely self-sterile, whereas those obtained from crosses involving amphiploids have given reasonably satisfactory seed sets. Cytological analysis of the F_1 hybrids has shown that bivalent formation in the former group of crosses was markedly lower than in the amphiploid parent involved, the mean values being 7.8 bivalents for the hybrids compared with 14.34, whereas in the amphiploid × amphiploid crosses pairing was similar to that observed in the parental plants.

In contrast with the wild base 6*X* amphiploid × *A. sativa* hybrids in which separation of the spikelet from the peduncle by fracture was partially dominant over the shedding base, the hybrid derived from the cross wild base type 6*X* amphiploid × cultivated base type 6*X* amphiploid exhibited a complete reversal of the dominance relationships, the shedding base type being wholly dominant over the normal base as found in the diploids and tetraploids.

A survey of the amphiploid material revealed the presence of chromosome mosaics in varying frequencies. In general, the frequency of cells with aberrant numbers of chromosomes in pollen mother cells ranged from 5 to 10% but, as shown below, unusually high frequencies were recorded for the following two amphiploid plants :

Plant number	*Frequency of cells with the following chromosome numbers*											*Total cells*	*Percentage mosaics*
	21	33	34	35	36	37	38	39	40	41	42		
Cc 4387/10	–	–	–	2	–	6	4	1	3	8	3	27	89
Cc 4435/1	1	1	2	–	3	6	8	13	7	7	18	66	70

Crosses between the tetraploid species, *A. barbata*, *A. abyssinica* and *A. vaviloviana* revealed the presence of structural interchanges in some of the hybrids. In hybrids between *A. barbata* and *A. abyssinica* an association of four chromosomes appeared in approximately 15% of the cells suggesting heterozygosity for a small interchange segment. *A. barbata* × *A. vaviloviana* showed one association in 54% of the cells and two associations in 18% of the cells analysed, thus indicating two separate interchanges. This was con-

firmed by the *A. abyssinica* × *A. vaviloviana* hybrid where a single association appeared in 65% of the cells compared with 72% of the cells in *A. barbata* × *A. vaviloviana*.

Inter-hexaploid species hybrids also revealed the presence of interchanges, and in *A. sterilis* the presence of multivalent associations was observed in hybrids between types from different geographic regions. The presence of these interchanges in the *Avenae* must be more widespread than has been hitherto suggested, but their full extent can only be discovered by systematic hybridization and cytological analysis of as many types and species as possible.

Agronomy studies (E.T.J. and I.T.J.)

The seed rate experiment carried out in 1954 and 1955 was repeated in 1957 and 1958, the randomized block layout previously used being changed to a split plot design in an attempt to gain more precise information regarding the interaction of varieties × seed rates.

In 1957 the main plots consisted of the same four varieties: Maldwyn S.221, Milford S.225, Victory and Marvellous; and the sub-plots of the three seed rates, low (69 lb. per acre), medium (137 lb.) and high (206 lb.). Each sub-plot comprised 4 drills, 1 ft. apart, the two central drills being harvested, one for yield of grain and straw, the other for detailed panicle and culm analyses. Yield figures for 1957 are as follows:

Yield of grain in gm. per 10 ft. of drill
(drills 12" apart)

	Seed rate			
Variety	*Low*	*Medium*	*High*	*Variety means*
Maldwyn S.221	261	278	268	269
Milford S.225	209	258	255	241
Victory	201	242	268	237
Marvellous	230	227	244	234
Seed rate means	225	251	259	245

L.S.D. between variety means (P = 0.05) = 25.9 ; (P = 0.01) = 35.8
L.S.D. ,, seed rate ,, = 13.7 ; ,, = 18.4
L.S.D. ,, seed rate means for one level of variety (P = 0.05) = 27.5
L.S.D. ,, variety means for one level of seed rate (P = 0.05) = 34.3

The yield figures show that on the basis of the variety means Maldwyn S.221 has given a significantly higher grain yield than any of the others and that the medium and high seed rates have given significantly greater mean yields than the low seed rate. The interaction varieties/seed rates is significant ($P = 0.05$) indicating that varieties were reacting differently to seed rate.

Maldwyn S.221 and Marvellous were able to maintain equivalent grain yields over the three seed rates, although the latter variety showed an appreciable reduction on decreasing the seed rate from high to medium, and generally throughout the experiment its yield was low. Victory began falling off in yield at the medium seed rate, but at the low rate of seeding, yields of this variety and also of Milford S.225 were significantly decreased ($P = 0.01$).

In 1958, as in 1955, varieties produced better grain yields under high and medium seed rates than under low, the varieties best able to maintain their yields under the low seed rate being Maldwyn S.221 and Marvellous.

Analysis of variance of the weights of saleable grain (grades 1, 2 and 3) revealed significant differences between varieties and also between seed rates. Low seed rates gave significantly higher graded weights than medium and high, the latter yielding similar weights of saleable grain. It would seem that under the low seed rate there has been an increase in either the average size of the grain, or in the proportion of large to small grain or possibly in both.

Straw yields did not show significant differences between varieties, nor between seed rates, and the interaction varieties/seed rates also was not significant.

Spring barley (J.D.H.)

The F_1 and F_2 of the barley diallel (XC 26) involving 12 lines of barley were grown in the field in 1957 as spaced plants, and 3,600 plants were scored in June for date of ear emergence, height and virus infection. At maturity the number of fertile tillers, height and weight of seed per plant were recorded. In 1958, F_2 plants from a portion of the diallel were space-planted in the field and various measurements obtained to assess variation within families. Statistical analysis of the data and the study of subsequent progenies should give an indication of the value of the diallel cross technique in commercial cereal breeding.

Sixty of the most interesting varieties from the barley collection were grown again in observation plots and their characteristics noted; the most promising will be used to expand further the barley breeding programme which is aimed at developing a feeding barley for Western conditions.

FIELD BEANS

Breeding studies in field beans (D.G.R.)

Over the two years under review investigations into the problem of self-fertility in relation to possible methods of improvement were continued, particular attention being given to the following aspects: (i) the number of mature flowers and potential ovules produced by the plant; (ii) the proportion of these ovules which, if fertilized, the plant is able to support; (iii) the effective pollen which becomes available for fertilization and (iv) the subsequent development, or abortion, of the fertilized ovules.

The first two factors are under genetic control and involve the fecundity of the plant. The third factor comprises the complex situation which arises from insect pollination, the necessity for flower-tripping, and the capacity of foreign pollen to grow better than self-pollen. Finally, the subsequent development of the ovules may be prevented either by direct zygotic infertility or *via* endosperm failure. Superimposed on these factors are the environmental conditions of light, temperature and nutritional effects which also influence seed setting.

In an attempt to separate the genetic and environmental factors a diallel cross was made between six parent plants. Five flowers were taken for each cross and the analysis was based on the total number of seeds produced. The progeny from this diallel cross was grown in an insect-proof greenhouse and allowed to set seed by selfing.

Variation in seed-setting on selfing followed a continuous distribution, corresponding with what might be expected from a system operating at the zygotic level. Self-fertility was dominant to self-sterility. The ability to set seed without the aid of flower-tripping appeared to be dominant to the necessity for tripping and, on the basis of these observations, the following hypothesis has been put forward to account for the type of self-sterility encountered in the field bean.

In common with the other *Papilionaceae* where the general trend towards increased heterozygosity has developed a strong self-incompatibility system, the ancestor of the field bean was most probably self-incompatible. The entomophilous flowers and tripping mechanism support this suggestion. Such a system, however, is inconsistent with cultivation for grain production where considerable selection pressure is exerted towards uniformity and hence inbreeding. This pressure is further increased when insect pollina-

tion becomes unreliable, as instanced in beans under British conditions. A strong oppositional self-incompatibility system would be expected to break down at the pollen inhibitory level (c.f. *Primula sinensis*) leaving a residual system comprising the entomophilous flowers and tripping mechanism with the self-pollen inhibition being modified to one favouring cross-pollination. The many deleterious recessive genes invariably accumulated by a self-incompatible organism would now restrict gene combination, particularly following selfing. Such a system of genes operating at the zygotic level could effectively take over the function of the original oppositional system and produce a new balanced mechanism of control at a lower level of hybridity. This new balanced mechanism now appears to operate in field beans.

In addition to the above investigations the programme of inbreeding was continued. Progress has necessarily been slow, but none the less improvement in the mean self-fertility of some populations was obtained, as shown in the table below:

Progress of inbreeding in a population of tick beans

	Pollination conditions	*Material*	*Percent flowers forming pods*	*Percentage sterile plants*
1955	Open-pollination	Original	23.6	0
1956	Selfing (tripping)	I_0	7.3	4
1957	Selfing (no tripping)	I_1	3.7	20
1958	Selfing (,,)	I_2	5.1	2

Flowers were manipulated to assist tripping in 1956, but during 1957 pod-setting was completely unaided and may be taken as an estimate of the capacity of these plants to set seed without tripping.

Since self-fertility and inbreeding are necessarily long-term projects, more immediate yield improvements are being sought by the development of synthetic varieties.

Improved pod-setting in hybrid plants of field beans was confirmed. Hybrids obtained through inter-pollination in the field between alternate rows of the white flowered line Ch 170, and a pale mauve flowered line, C.74, could be detected in the seedling stage in the Ch 170 progeny by the presence of colour in the stipule spot at the base of the second or third leaf, and were thus recognisable for study. For purposes of comparison an inbred line of Ch 170 from the greenhouse, and seed of a commercial tick bean, were included

in the 1957 trials. Mean pod number per plant as shown below was found to be highest in the hybrids :

	Mean pod number (per plant)	*Per cent of Ch* 170
Ch 170 hybrid plants	24.1	143
Commercial tick	21.7	129
Ch 170 (white)	16.8	100
C. 74 (mauve)	16.6	100
Ch 170 inbred	12.4	74
Least sig. diff. at 5%	1.94	12%

This superiority of hybrids over population plants which are partially inbred is emphasised by the following data from a population of Ch 170 :

	Mean number of			*Percent flowers*
	Flowers	*Pods*	*Seeds*	*giving pods*
Ch 170 coloured (hybrid)	123.9	24.1	69.9	19.9
Ch 170 white (population)	100.9	14.0	33.1	14.1

A considerable increase in yield follows from such improvement in seed number in hybrid plants and the possibility arises of employing this hybrid vigour in a breeding programme.

The reliance upon insect pollination in the field introduces additional difficulties, but in spite of this problem, breeding techniques involving hybrid production are being investigated and an estimate of possible improvement in yield is being sought. Progeny tests based on top crosses, polycrosses and diallel crosses, as estimates of combining ability, are in progress, and different types of synthetic varieties are being evaluated, together with techniques for their commercial production, including forms of recurrent selection.

BRASSICAE CROPS

Agronomy trials (T.D.J.)

During the two seasons under review trials were continued of commercially available varieties of kale and rape to assess their agronomic characteristics for future use in the breeding programme.

Rape. In each season replicated trials of rape, rape-kale and hungry-gap kale were laid down with two varieties of turnip rape for comparison. The trials indicated that only small differences exist between the various commercial stocks of any one type in terms of total yield, with only slightly greater variation between types.

Yield of some rape types in potentiality trials

Strain	*Yield (tons per acre)* 1956–57	1957–58
Rape-kale (a)	6.6	7.3
,, (b)	6.6	8.8
Hungry-gap kale (a)	7.8	–
,, (b)	7.9	8.3
Dwarf rape	7.3	7.8
Giant rape (a)	7.6	10.4
,, (b)	6.8	11.4
Asparagus kale (a)	–	9.5
,, (b)	–	8.4
Turnip rape (a)	–	7.8
,, (b)	–	6.2

The yield variations are not large, but other important agronomic differences were observed, namely, the greater winter hardiness of the hungry-gap kale and rape-kale types, the shorter time to maturity of the turnip rapes and the greater competitive ability of giant rape.

Kale. Replicated trials of marrow-stem kale were laid down at lowland and medium altitude centres. In each year it was found that in general only small differences in yielding potential existed, although there were significant differences in percentage leafiness. The table below shows the results obtained during 1957 at the lowland centre :

Yields and leafiness of 6 strains of marrow-stem kale grown at a lowland centre and harvested in mid-November

	Total yield tons/acre	*Dry matter cwt/acre*	*Percentage leaf*
Chou moellier blanc	13.8	46	31
Commercial strain (a)	13.1	44	37
,, (b)	12.8	44	39
,, (c)	11.5	39	40
,, (d)	11.3	39	43
Goliath	9.8	36	50

It will be noted that there is an inverse relationship between total yield and leafiness which appears to be because of a high degree of uniformity of leaf production in all varieties, the variations in overall yield being due almost entirely to differences in stem growth.

Similar trials of thousand-headed kale indicated only small differences between stocks except that certain continental types were able to produce a large bulk of leafy material and were somewhat intermediate in habit between typical thousand-headed and marrow-stem kales.

Rape and kale mixtures. A trial of a number of rape with kale mixtures and pure stands of the same varieties was sown in 12" drills to assess the relative competitive yielding ability of the varieties in the mixtures. For the purposes of the trial all seed rates were 5 lb. per acre composed of either equal parts of the two varieties in the mixture or pure (commercial) seed.

On separating the mixed samples after harvesting in October, it was found that the proportions of rape and kale present bore no relationship to the relative yield potential of the varieties grown as pure stands. In all cases the rape, and to a lesser extent, the rape-kale, due to greater aggressiveness in the early stages of growth, dominated the mixtures, whereas in the pure stands they were outyielded by Canson and marrow-stem kale.

Yield, tons per acre, of varieties of rape and kale compared with mixtures of varieties

Variety or mixture	*Yield*	*Percentage yield due to first component*
Giant rape (a)	5.1	–
Rape-kale (b)	4.8	–
Canson kale (c)	6.9	–
Marrow-stem kale (d)	7.2	–
a+c	3.7	82
a+d	6.4	82
b+c	5.3	59
b+d	4.3	57

BREEDING INVESTIGATIONS (T.D.J.)

Rape. Numerous hybridizations have been made between varieties of rape. In some of the crosses the F_1 progenies exhibited markedly superior vigour to the parent varieties, especially in respect of initial rate of growth.

Tests carried out on the variety of clubroot-resistant rape bred in New Zealand have shown that this rape is capable of establishing a stand and growing under very high levels of soil infection, but that later in the growing season it is attacked and eventually severely damaged. Nevertheless this initial resistance is important and numerous hybridizations have been made in an attempt to incorporate resistance into native British rapes. Using a greenhouse inoculation technique it has been found that the F_1 generation from such crosses shows a high degree of resistance and that there is clear-cut segregation in the F_2.

Kale. Hybrids between a wide range of *B. oleracea* varieties did not exhibit as marked a superiority over the parent varieties as had been observed in some of the rape hybrids. However, certain combinations appear promising, particularly those of kohlrabi with marrow-stem and Canson kales. The former produces shorter, leafy marrow-stem kale types and the latter gives highly branched, leafy plants with stems somewhat softer than those typical of thousand-headed kale.

In 1957 the X_1 generation from seed of Canson and marrow-stem kale irradiated with 30*Kr.* and 60*Kr.* were grown in isolation plots in the field. Considerable variations in morphological characteristics of the individual plants were observed, attributable probably to the inherent variability of the varieties used rather than to direct effects of irradiation. However, it was noted that the percentage of plants which failed to flower in the harvest year was greater in the material which received 60*Kr.*, and also, that these plants were slower to pass through the early stages of germination and development :

Percentage of surviving plants from irradiated kale seed failing to flower in the harvest year

	Treatment	
	30*Kr.*	60*Kr.*
Marrow-stem kale	11%	41%
Canson kale	2%	10%

METHOD OF HANDLING BREEDING MATERIAL OF THE KALES (T.D.J.)

For hybridization and individual plant selection it is desirable to grow the selected parental material in the greenhouse so that ripe seed may be obtained sufficiently early in the summer to allow the following generation to attain full vegetative vigour and thus to facilitate further selection in the field. It was considered essential that some means be found to deal with the large amount of bulky field material within the rather restricted space of a field laboratory. The technique adopted, therefore, has been the use of vegetative propagation of selected parental material. Various methods of propagation, using different parts of the plant as propagules, have been described ; the use of axillary bud cuttings has proved most suitable for the present requirements, having the added advantage that parent plants can remain *in situ* in the field for further observation.

Plants are selected in the field in early winter, and one or more axillary buds removed, preferably from about two-thirds up the stem ; buds from low position tend to produce only very small plants whilst those from near the terminal bud, and the terminal bud itself, are more difficult to root.

A tangential segment of the stem about 2″ long bearing the selected bud and including some of the woody tissue of the stem is removed with a sharp knife. All expanded leaves, including the subtending leaf, are removed ; the cut surface of the propagule is dusted with a standard root-promoting preparation, and planted firmly in moist sterile compost in a 5″ earthenware pot and kept moist in a warm greenhouse. With the aid of supplementary lighting to extend the day-length to 18 hours, root formation is accelerated and there is less likelihood of loss of propagules through fungal attack ; under these conditions nearly 100% success may be expected. Furthermore, the use of supplementary lighting promotes more rapid flowering, ensuring ripe seed in adequate time for sowing in the field.

The method of handling described can be applied both to plants for controlled hybridization and to populations required to intercross freely, provided in the latter case effective isolation of the population is ensured. At the time of year when such plants are induced to flower the shortage of insect pollinators occasionally necessitates hand pollination, but for the same reason adequate isolation is less difficult to secure than later in the year.

GRASSLAND AGRONOMY

Ll. Iorwerth Jones

The main investigations were again concerned with the evaluation of varieties of herbage plants for upland and lowland conditions.

Assessment of grasses and clovers

Studies were designed to provide data on the behaviour of potential varieties in relation to the established varieties, and to compare the established varieties under a range of environmental conditions, including management, manuring and altitude.

Perennial ryegrass (D.G.M.). Two potential varieties of perennial ryegrass, Ba 6280 and Ba 6293, were compared with established varieties under a series of managements at upland and lowland centres. Ba 6280 grew more vigorously during the autumn of 1957 but suffered from winter burn at an earlier date, whilst Ba 6293, although not so vigorous during autumn, maintained its green colour throughout the winter better than any of the others, and produced substantially more herbage than Ba 6280, S.23 or S.101 in the spring of 1958. The management of the swards in autumn/winter 1957 had a considerable influence on the relative growth of the ryegrasses in the following spring and early summer.

Twenty-four varieties of perennial ryegrass were compared under rotational grazing management in swards of one ryegrass plus white clover at upland and lowland centres. The varieties were drawn from Sweden, Denmark, Germany, Belgium, France, Netherlands, Ireland and the United Kingdom and were sown in April 1957.

Appreciable differences in productivity and greenness were evident by December of the seeding year, the varieties from Sweden, Denmark, Germany and Northern Ireland were least impressive, while the early Hooitype C.B. (Netherlands) and the late-flowering Sceempter Weidetype (Netherlands), and Ba 6293 (Welsh Plant Breeding Station) appeared to be the most productive at that period.

In spring 1958 Aberystwyth S.24 and Devon Eaver gave the best bulk of herbage of the early-flowering varieties, but Devon Eaver was appreciably more stemmy. The late-flowering varieties as a group produced substantially heavier yields of herbage than the early-flowering in March and April; Hunsballe II and Sildig Ötofte II (Denmark), Glasnevin Leafy (Ireland), Hooitype Barenza and Weidetype Barenza (Netherlands) and Aberystwyth S.101

produced over 3,000 lb. dry matter per acre before the end of April. In the silage cut taken in June there were no significant differences in yield between the early-flowering varieties, but in the late-flowering group Viktoria and Glasnevin Leafy gave significantly poorer yields than the average of the group.

Cocksfoot (D.G.M.). Trials to compare a potential variety of cocksfoot Bc 4075 with S.37 and Danish showed that the inclusion of perennial ryegrass as a companion in the seeds mixture suppressed the development of Bc 4075 to a greater extent than that of S.37 and Danish, but in neither case was the total yield of herbage reduced. Bc 4075 was dormant in the 1957/58 winter, and in this respect it resembled Danish cocksfoot rather than S.37, which maintained its green condition much better into the winter. It produced a heavier yield of herbage in early spring, followed by a lighter crop of hay than either S.37 or Danish. The aftermath growth of Bc 4075 was as good as the other two varieties.

Timothy (D.G.M.). Canadian timothy proved more vigorous in the autumn of the seeding year than S.51, Scotch or the potential variety Bd 2308. In the first harvest year the mixtures based on Bd 2308 gave a significantly higher yield of hay than those based on S.51 timothy ; the yield of mixtures based on Scotch and Canadian were intermediate. In another trial, mixtures based on Bd 2308 produced more hay than those based on S.48.

Meadow fescue (D.G.M.). The potential varieties Bf 601 and Bf 602 gave heavier yields of hay than S.53 in the simple meadow fescue/white clover mixtures, but in those containing meadow fescue, timothy and white clover the heaviest yields of herbage were obtained from swards based on S.53 meadow fescue.

Red clover (D.G.M.). In the seeding year broad red clover proved more aggressive towards the grass components of a sward than either S.151 or S.123 red clovers. The inclusion of grass with red clover resulted in an increased yield of herbage in the seeding year but all red clovers were partially suppressed by the grass component ; S.24 perennial ryegrass was more aggressive in this respect than S.48 timothy. Yield of hay in the first harvest year varied considerably between one red clover and another, and in one investigation the red clover which produced the lowest yield at the lowland centre gave the heaviest yield at the upland.

Following the harvesting of hay on clover plots in 1958 it was noticed that where hay had been left on plots for 7–10 days after cutting because of continuous rain there was a high mortality amongst the red clover plants, amounting to between 80% and 95%

of the initial population, but where the hay was removed within 24 hours few, if any, casualties occurred. Broad red clover suffered less damage from the effect of hay lying on the sward than some of the late-flowering varieties.

Phalaris (A.H.C.). In previous investigations the take of *Phalaris* S.230 was unsatisfactory, and its establishment was again studied. Seed was sown in drills 1 ft. apart at 2, 5 and 20 lb. per acre respectively and in broadcast plots at 20 lb. per acre. Sowings were made each month from April to December 1957. The seed rates of 5 lb. per acre in drills and 20 lb. per acre in swards were satisfactory. The April and May sowings produced most herbage in the seeding year and were the only swards in which heading occurred; there was a sharp decline in growth of *Phalaris* sown after June. Mid-September was the latest date of sowing for a satisfactory establishment, but very little growth was obtained from this during the seeding year.

Experiments were laid down in April 1957, to test the influence of management on the establishment and herbage production under sward conditions of *Phalaris* S.230, tall oat grass Bm 102, and sweet vernal grass Bs 1973, Each variety was subjected to five systems of management (a) frequent grazing ; (b) rotational grazing ; (c) one cut for silage followed by grazing ; (d) cut for hay followed by grazing and (e) cut for hay followed by the conservation of the aftermath as foggage for winter grazing. The plots in treatment (e) received 5 cwt. nitrochalk in mid-September.

The *Phalaris*, sown broadcast at 20 lb. per acre with 2 lb. of S.100 white clover, was slow to establish, but an excellent take of clover was obtained. On 2 July 1957, the yield of dry matter was 640 lb. per acre, while on adjacent plots sweet vernal yielded 1,390 lb. and tall oat grass 2,550 lb. per acre. Later in the year S.230 produced a higher yield than either. The *Phalaris* herbage was not readily eaten by sheep and they scoured rather severely. The plots remained very green in their first winter, even where there was a good bulk of herbage. During 1958 *Phalaris* thinned out under all managements and it did not appear to be suitable for use in swards.

A comparison of *Phalaris* S.230 with timothy S.48 sown in May 1958, showed that the timothy was slightly more vigorous, both in germination and initial stages of growth, but by early August *Phalaris* was the more productive, yielding 1,787 lb. of dry matter per acre as against 1,625 lb. of timothy. All lambs grazing the *Phalaris* swards in August scoured, and lost 5½ lb. per lamb in

3½ weeks, whereas similar lambs grazing S.48 did not scour and maintained their weight.

The establishment of two potential varieties of *Phalaris arundinacea*, Bs 2566 and Bs 2567, was satisfactory and heavy crops of rather stemmy hay were obtained in the seeding year, but the clover was severely checked under infrequent defoliation. These varieties were palatable to sheep even when dry matter yield exceeded 2,000 lb. per acre. One variety persisted well in the first harvest year, the other thinned out markedly.

Tall oat grass Bm 102 (A.H.C.). This potential variety was sown at 40 lb. per acre with S.100 white clover at 2 lb. Establishment and early growth were rapid and a hay crop was obtained in the seeding year ; there was a satisfactory take of clover. The grass was readily eaten by sheep and its persistency under various managements appeared satisfactory in the first harvest year.

Sweet vernal grass Bs 1973 (A.H.C.). This was sown at 35 lb. per acre (57% germination) with 2 lb. of S.100. A dense sward with a low clover content developed rapidly ; it was readily eaten by sheep. The herbage became brown in October except where 5 cwt. of nitrochalk had been applied in mid-September, and this remained green until January. Persistency in the first harvest year appeared satisfactory under all managements.

The influence of the ley on the succeeding arable crop (I.D., (A.H.C.). Four ley experiments were ploughed in 1957 and 1958, and sown to oats to determine the influence of the preceding swards on the following arable crop. Samples of the oat crop were taken during the growing season and also when the crop was ripe.

In one investigation an estimate was made of the friability of the furrow slices of the different swards after ploughing in February, 1957. Oats were sown on 2 April and the yield of herbage measured at the end of May and early in July, also the yield of grain and straw when the crop was ripe. The data indicate that the character of the previous sward had a considerable influence on the development and final production of the following oat crop. This is shown bv the table average of 9 replicates (I.D.).

Sward 1952–1956	*Clover** 1956	*Friability of soil***	*Relative yield of oats* 1957 28/5	8/7	*Ripe stage* *Straw*	*Grain*
S.22 Italian ryegrass	69	2.7	100	100	104	–***
S.24 perennial ryegrass	25	4.9	82	90	100	100
S.23 ,, ,,	16	6.3	90	75	87	86
S.170 tall fescue	8	9.7	78	75	75	87
S.143 cocksfoot	1	8.5	73	68	73	92
S.51 timothy	3	9.0	58	61	63	81

*Percentage of ground covered by clover in 1956.

**Friability of furrow slice, 10 = furrow slices unbroken, 0 = furrow slices unrecognisable because of friable nature.

***Yield not recorded on account of grain shedding.

A considerable amount of grain shedding occurred on the plots following Italian ryegrass, but only a small amount on those following S.23 and S.24 perennial ryegrass ; there was no shedding on other plots.

In these studies it was not possible to assess the direct influence of the grass variety on the growth of the succeeding crop because of the variable clover content of the swards during the year before ploughing (1956). The following figures indicate a correlation between the amount of clover in timothy swards in the year prior to ploughing and the early vegetative growth of the succeeding oat crop, average of 9 replicates : (I.D.).

Variety of timothy in sward 1952–1956	*Percentage ground covered by white clover July* 1956	*Relative yield of oat herbage* 6 *June* 1957
American	32	100
Bd 2308	13	89
S.51	1	77

Data from other trials show that the yield of oats was much higher after swards previously grazed regularly, compared with those which had been defoliated by the mowing machine.

ASSESSMENT OF HERBAGE VARIETIES : TECHNIQUE STUDIES (D.G.M.)

Six swards based on different grasses sown in 1955 were each subjected to six treatments to study their behaviour and productivity. The treatments consisted of grazing *versus* mowing, with and without animal droppings or compensatory artificial fertilizers. The grazing treatments were carried out by folding adult wethers fitted with harness to collect the dung and urine where necessary.

Herbage production varied considerably from one treatment to another on each type of sward, and from one sward to another for each treatment. Growth was relatively uniform on every plot under all treatments except the natural grazed swards, where the distribution of dung and urine was uneven. White clover was more plentiful on mown swards receiving the same quantity of dung and urine than on grazed swards, but was almost completely suppressed on mown plots which received artificial fertilizers in lieu of dung and urine. In the absence of dung, urine and artificial fertilizers the mown swards produced more herbage than the grazed, but this

difference was less pronounced in the dense swards based on S.23, S.48 or S.26. The response to the return of dung and urine varied from one grass to another : it was greater on swards based on S.22 Italian ryegrass than on those based on S.23 perennial ryegrass or S.48 timothy. Also the application of artificial fertilizers produced a more marked increase in yield of herbage from the S.22 Italian ryegrass swards than the others.

The evidence suggests that method of defoliation and the return or no return of dung and urine or the equivalent CaNPK in artificial fertilizers, affect swards based on the different grasses to varying degrees.

Animal production (ll.i.j.)

During the third and fourth harvest years the swards based on S.170 tall fescue again provided more spring grazing than those based on S.24 perennial ryegrass, but unlike the previous two years the production per beast per day was higher on the ryegrass swards. The grazing provided by the two swards in terms of animal grazing days as well as the increase in live-weight of cattle, are shown by the following figures, average for 1957/58 :

		No. of sheep- or cattle-grazing days per acre per annum	
		*S.*24	*S.*170
March-April :	Sheep	172	224
April-May :	Cattle	82	117
May-October :	Cattle	332	330
		Live-weight production (lb.)	
Gain of cattle per acre per annum		702	656
Gain per beast per day		1.70	1.47

Hill land investigations

Native hill swards (w.e.j.m.). The experiments on the improvement of native hill pastures of *Molinia/Nardus* and of *Festuca/Agrostis* types were continued on two hill farms in the Bontgoch district. Where the treatment consists of controlled grazing with sheep on limed and fertilized swards, the ryegrass, cocksfoot, timothy, rough-stalked meadow grass and wild white clover which gradually appeared among the native herbage since 1930 continued to maintain, and in certain instances to increase, their contribution. The unfenced and freely grazed plots of the same series where lime

and fertilizers have been given have considerably improved in botanical composition, but perennial ryegrass, cocksfoot and timothy have not established. A number of unfenced hill swards on which seeds mixtures of grasses, white clover and herbs have been surface-sown in addition to the application of lime and fertilizers, are now a blend of native and sown species. Two years of treatment showed a marked increase in clover and the better grasses and a continuation of the technique gave further improvement. Interesting botanical changes have occurred on manured native-species swards under a hay and aftermath cutting system.

Improvement by reseeding (LL.I.J.). Observations on swards sown in 1949 show that those based on S.23 perennial ryegrass are outstanding with little sign of reversion, whereas most of the swards based on other species or other ryegrass varieties are in various stages of reversion. Swards of ryegrasses maintained their composition better than those of timothy, meadow fescue or cocksfoot, but amongst these latter S.50 timothy and S.53 meadow fescue were the most successful.

Production of improved and native swards (LL.I.J.). The measurement of sheep production on hill land at 1,200′–1,300′ subjected to different treatments was continued. The areas reseeded in 1944 were still far more productive than the native unimproved swards, and the following figures, averaged for 1956/58, indicate the lamb production of these pastures :

	Native hill pasture (unimproved)	*Improved hill pastures sown with*	
		Commercial varieties	*Leafy bred varieties*
No. of ewes grazing per acre	1.8	3.5	3.5
,, ,, lambs reared per acre	1.6	3.5	4.0
,, ,, ,, ,, ,, 100 ewes	92	101	116
Average weight per lamb*	45 lb.	49 lb.	49 lb.
,, value per lamb*	72/6	79/-	80/-
Average weight of lamb produced per acre per annum	72 lb.	157 lb.	186 lb.
Average value of lamb produced per acre per annum	111/6	245/-	298/-

*Lamb data at weaning based on single lambs.

The rate of stocking on all plots was slightly higher than for the previous twelve years, chiefly because of the complete absence of rabbits, and, to a lesser extent, because of the comparatively mild winters and good weather during the growing season.

The value per acre of ewes and lambs drafted from each plot on 20 September 1957, and the cost of wintering, are shown by the following figures :

Value per acre of sheep drafted on 20/9/57	*Native hill pasture (unimproved) Plot C*	*Improved hill pastures sown with Commercial varieties Plot A*	*Leafy bred varieties Plot B*
Ewes	40/6	67/6	87/6
Lambs	79/6	202/-	254/-
Total	120/-	269/6	341/6
Cost per acre of wintering, 1956/57	66/8	92/-	85/-

SPECIAL STUDIES ON THE BEHAVIOUR OF GRASSES

Ryegrass (A.G.D.). Ryegrass plants in a sward 2–3 years old were compared with those spaced out at the time of sowing, and it was observed that there was a comparative absence of low-yielding types in the former, suggesting that the less vigorous plants had been suppressed in the sward. This was more noticeable in S.24 than in S.23 and Kent, and in all three it was more pronounced amongst the plant population of swards managed for hay and aftermath than those regularly defoliated.

Further evidence on the interaction between plants of the same variety in a sward was obtained when tiller units of ryegrass plants already tested for yielding ability were planted 2″ apart. Three types of swards were produced, one based on high-yielding plants, the second on low-yielding and the third on alternate high- and low-yielding. The development of tiller units in the swards of high-yielding plants was more vigorous, but the difference between the high- and low-yielding plants, both in terms of yield of herbage and of tillering, was far more pronounced when grown in a mixed sward where the high-yielding plants generally suppressed their less vigorous companions.

A study of spacing S.24 perennial ryegrass at 2″, 4″, 6″ and 12″ respectively, with three levels of nitrogen, showed that in the first harvest year the 2″ spacings produced the highest number of tillers per sq. ft. until the middle of July, but after that there were as many or more tillers in the 4″ spacing. There was a rise in number of tillers throughout the season at the 12″ spacing at all nitrogen levels, the 6″ and 4″ spacings which received 4 or 12 cwt. per acre of nitrochalk, and the 2″ spacing which had 12 cwt. In the absence of nitrochalk a reduction in tiller number was observed in the 2″ spacing as the season progressed.

Timothy (I.D.). Studies were conducted on two varieties of timothy, S.51 and Bd 2308, to investigate the relationship between spring growth and commencement of stem elongation, the utilisation of nitrogen in relation to the stage of growth, and the effect of cutting and manuring treatments on the seasonal distribution of the herbage produced.

Stem elongation of the majority of Bd 2308 tillers occurred during late April and the first half of May 1958, and in S.51 during the latter half of May and early June. Timothy S.51 produced more herbage than Bd 2308 throughout the winter months up to the end of March 1958, and their production during early April was about equal, but from mid April until June, Bd 2308 showed a progressive advantage over S.51. It is apparent, therefore, that although the time of the spring flush of growth is governed by the date of stem elongation and flowering, the early spring growth has no connection with date of flowering. This has also been observed within ryegrass and cocksfoot varieties.

The total response to nitrogen application varied from 11.9 to 47.7 lb. of herbage per lb. of nitrogen applied ; both figures relate to S.51, the former to plots manured 13 days before the first cut was taken on 7 July, and the latter to plots manured 30 days before a first cut was taken on 19 June.

The relative recovery growth of the two varieties following different dates of taking the first cut was clearly connected with the date of stem elongation, but stem length measurements were not a direct indication of this owing to the prostrate habit of the basal internodes of both varieties during the early phases of stem elongation.

Nitrogen applied in April stimulated earlier stem elongation. Consequently after cuts taken at critical dates in May the plots manured in April showed a thinner recovery and a lower production in the subsequent cut than those which did not receive nitrogen in

April. The data below refer to an instance when Bd 2308 was affected in this manner, but not S.51, owing to the later date of stem elongation initiation of the latter :

	Production lb.per acre between 12 May and 18 June		*No. of tillers per sq. ft. recovering after cutting on 12 May*	
	No nitrogen	*N applied 10 April*	*No. Nitrogen*	*N applied 10 April*
S.51	780	930	1001	971
Bd 2308	510	390	508	175

These results indicate the importance of interpreting both variety comparisons and fertilizer treatments in carefully defined terms relative to the growth stages of the grasses involved.

Various spp. (LL.I.J., W.I.J.D.). A study of the influence of plant spacing (spaced plants, drills and swards), nitrogen application and altitude, on a number of grass species showed that each of these factors influenced behaviour and herbage production of the grasses to a markedly different extent. This is illustrated by the following figures, which show the annual herbage yield of S.48 timothy relative to that of S.24 perennial ryegrass = 100 for each treatment :

	No Nitrogen	*N. applied 362 lb. per acre*
Swards	43	91
Drills	72	78
Spaced plants	112	129

The yield of herbage at the higher altitude was considerably less than at the lower and the differences between the locations was most evident in the swards, and least in the spaced plants. The application of nitrogen increased the yield of herbage for all treatments, but was far more pronounced in the swards than the drills whilst the influence of nitrogen on the spaced plants was relatively small. The data also showed how different species reacted to altitude, e.g. S.59 red fescue produced 22% less dry matter than S.170 tall fescue at the lower elevation, but 14% more at the upland centre. All data have not been analysed, but it is evident that location, fertilizer application and density of plants have a marked differential influence on the herbage production of the grasses.

INTERACTION BETWEEN THE COVER CROP AND THE UNDERSOWN HERBAGE (A.H.C.)

Undersowing with Italian ryegrass where nitrogenous fertilizers

were applied reduced the growth rate of the oat shoot, and in particular the yield of straw. The effect on grain yield was far less marked. In addition to reducing the growth of the oat shoot Italian ryegrass reduced the crude protein percentage of the straw. Both red clover and Italian ryegrass had little influence on the yield of the cereal cover crop in the absence of nitrogenous fertilizers.

STUDIES ON THE ROOTS AND STORAGE ORGANS OF HERBAGE PLANTS (A.T.)

These investigations were mainly concerned with the study of the relationship between the growth in weight of roots and shoots of young plants. Amongst the plants studied were a spring oat crop, plants grown from vernalised and unvernalised seed of S.23 perennial ryegrass, four varieties of ryegrass viz. *Westerwoldicum*, Irish, S.22 Italian and S.23 perennial, and grass plants subjected to various degrees of shading and drought conditions.

In all cases the relationship between root and shoot growth fitted the allometric formula $y = bx^k$ where y = weight of roots, x = weight of shoot, k = ratio of their log growth rates and b = value of y when x is equal to unity. Where plants flowered during the seeding year two values of k were needed, one for the early vegetative growth and the other for commencement of stem growth to full development, whereas for plants such as S.23 which produced no flowering heads in the seeding year, only one value of k was needed.

The following table, which gives the value of k, summarises the main findings :

Crop	*Value of k*
Oats	
During April	2.261 ± 0.030
May to July	0.555 ± 0.113
S.23 perennial ryegrass	
Vernalised	0.748 ± 0.080
Unvernalised	0.992 ± 0.090
Full sunlight	1.050 ± 0.017
Shaded	0.487 ± 0.067
Ample soil moisture	1.064 ± 0.049
Deficiency in soil moisture	1.267 ± 0.060

The investigations to study the influence of age of sward, botanical composition, location and system of cropping on the root weight, organic content of soil and soil structure were continued, but had to be curtailed after Dr. Troughton's departure to New Zealand in May 1958.

SEED MULTIPLICATION

Gwilym Evans

PRODUCTION OF FOUNDATION SEED

Herbage strains

First generation stocks from 37 clonal islands and 109¾ acres (second generation) of Foundation Seed of perennial ryegrass, Italian ryegrass and clover varieties, were harvested in 1957 and 116 acres of these species were sown, including 20 acres of the new variety S.100 " Nomark " white clover, which is intended to replace the present S.100 variety.

In 1958, 34 clonal areas of established and potential varieties were harvested and 8 new areas, including an initial seed island of a " nomark " red clover, were planted for the production of first generation seed stocks. In addition, 176 acres of perennial ryegrass S.24, S.101 and S.23, Italian ryegrass S.22, white clover S.100, S.100 " Nomark " and S.184, and red clover S.151 and S.123 came for seed harvest and 60 acres were sown for harvesting in 1959.

The reserve bank of Foundation Seed of clover varieties has proved invaluable in a succession of three poor harvests and in view of such uncertainty of weather it may be necessary to increase areas of each variety until ample reserves have been accumulated.

In 1956/57 sufficient Foundation Seed was distributed to the N.I.A.B. stock seed growers to sow 1,110 acres main crops, an increase of 20% on the previous year, while in 1957/58 Foundation Seed for 689 acres of main crops was distributed. This reduced acreage was due to an adequate carry-over of Stock Seed of certain grass varieties from the 1956 and 1957 harvest.

The acreage of seed crops of the Station's varieties inspected in 1957 for certification was 32,953, being the second highest total since the commencement of the Seed Inspection Scheme in 1940, while in 1958 the record of 36,693 acres were inspected.

Cereal varieties

In addition to nucleus stocks and crops of potential varieties grown for trials, 82 tons of Foundation Seed of 6 oat varieties bred at the Station, namely, winter varieties S.147, S.172, S.226, and spring varieties S.225, S.221 and S.220, were produced and distributed in 1956/57 to organizations operating Cereal Seed Crop Inspection Schemes; this includes a first release of the white winter oat variety Powys S.226.

In 1957/58, 62 tons of Foundation Seed of these six oat varieties were distributed.

In 1957 under the English Cereal Field Approval Scheme the Station's oat varieties covered 82% of the oat acreages inspected.

During 1958 Penrhyn S.234, a new winter oat variety, was multiplied on a field scale with a view to releasing Foundation Seed in the autumn.

RESULTS OF INVESTIGATIONS

The effect of undersowing on seed yield (H.M.R.)

The significant reduction in the seed yield of cocksfoot S.26 in its first harvest year as a result of undersowing in an oat crop, was related to a reduction in the number of inflorescences, and a decrease in the amount of seed produced per panicle. Extra nitrogen applied in spring was more effective in increasing both panicle numbers and weight of seed per fertile tiller than similar quantities of nitrogenous fertilizers applied in the previous autumn.

The best seed yield, 88% of Control figures, from undersown plots was obtained by blocking one corn drill in five, sowing the cocksfoot seed in the blank drill and applying extra nitrogen in the spring of the first harvest year. The grain yield was reduced by only 6% as a result of the missing drill whilst the first harvest seed yield of the cocksfoot was increased by approximately 20%.

The results in 1958 confirm previous findings which showed that a stand of cocksfoot produced significantly reduced seed yields in its first harvest year as a result of undersowing, but gave better yield than the control in the second harvest year.

Seed yield in relation to clonal propagation (G.E.)

Divided clones of S.24 perennial ryegrass and S.26 cocksfoot planted in the spring of 1956 failed to produce appreciable quantities of seed in the following summer. The yields from plantings made in the autumn of 1955 were also low, but considerably higher than those from the 1956 spring planting. Full seed crops were obtained from all these propagants in 1957, the later established clones producing more seed than the earlier.

Single tiller units of S.24 perennial ryegrass overwintered in the greenhouse, produced at least as much seed as four-tillered units in the year after planting in the field, and the seed yields compared very favourably with those from four- and twenty-tiller units or quartered plants established directly in the rows.

Clones of cocksfoot S.26 produced less seed after treatment with nitrogen at anthesis; this reaction agrees with the results obtained from clones of perennial ryegrass S.24.

Clones of S.26, after defoliation to prevent the production of seed, produced superior seed yields in the following harvest year than comparable clones harvested for seed in the previous year.

EFFECT OF SOWING RATE ON SEED PRODUCTION (G.E.)

In the first harvest year (1957), S.24 perennial ryegrass gave significantly higher seed yields from sowings of 1 and 5 lb. per acre in 27" wide drills than from a heavier seed rate or from plants spaced 1 ft. apart. No significant differences in yield appeared between 1 and 5 lb. sowings and no advantage was derived from "gapping" the 5 lb. sowing.

In S.170 tall fescue and S.53 meadow fescue significantly better first harvest year seed yields were obtained from spaced plants than from 1 and 5 lb. sowings; an abnormally heavy seed rate depressed the seed yields severely. The reaction of S.37 cocksfoot and S.230 *Phalaris* hybrid to plant densities was similar to that of the fescues, except that the very heavy seed rate of 50 lb. per acre did not depress the yield to the same extent, especially in the cocksfoot. Nitrogen failed to eliminate the unfavourable effect of high seed rate in any of the varieties or of spacing in the perennial ryegrass plants.

The second harvest year (1958) seed yields of S.24 perennial ryegrass in 27" wide drills contrasted sharply with results obtained in the first harvest in that the denser sowings now showed the better results. Yields from spaced plants were the lowest and agreed with the results from the first harvest. Gapping of drills sown at the standard rate again showed no advantage.

In the no-nitrogen treatments the seed yields in the second harvest year from S.170 tall fescue, S.37 cocksfoot and S.230 *Phalaris* hybrid decreased as the seed rates increased. The yields from the spaced plants were best, as in the first harvest year, but spaced plants of S.53 meadow fescue, as in S.24 perennial ryegrass, yielded less seed than at the 1 lb. rate. S.230 *Phalaris* showed the greatest relative response to nitrogen in terms of seed yield.

The autumn cutting of S.24 grown in wide drills was followed by reduced seed yields in the first harvest year (1957), but nitrogen applied as late as anthesis was able to correct this disability, and it also significantly increased the seed yield of plots left uncut in the autumn; in 1958, the second harvest year, autumn defoliation of S.24 increased the yield. The sharp frost in the spring of 1958

seemed to have had a greater adverse effect on the undefoliated plots which carried greater growth throughout the winter.

Effect of defoliation on seed yield (H.M.R.)

The effect of defoliation with and without additional nitrogen on the seed yield of S.170 tall fescue showed that neither the cutting of the vegetative growth at various dates from October until the appearance of incipient inflorescences, nor the application of extra nitrogen, significantly affected the number of fertile tillers or the yield of seed in the fifth harvest year.

The marked increase in the second and third harvest years in number of fertile tillers, and in the seed yield as a result of October defoliation, was not maintained in the fourth year (1957), and it appears that in 1958 a *reduction* in yield followed defoliation at this period. It seems from these data that old stands might be more sensitive to the effect of defoliation than newly established crops.

The burning of tall fescue aftermath in August 1956 did not affect seed yield in the following harvest, but after burning in October the quantity of leafage developed before winter was considerably less and there was a reduction in the amount of winter burn, coupled with an increase in the number of fertile tillers and in total weight of seed. As in the previous harvest, burning in March significantly reduced the seed yield.

A reduction in seed yield of tall fescue S.170 after burning in October 1957, contrasts with the increased yield after October burning in 1956 and is in sympathy with the yield obtained after October defoliation in 1957. February and March (1958) burning, as in the previous two harvest years, significantly reduced the yields of seed.

Effect of applying nitrogen in spring (H.M.R.)

Under low fertility conditions nitrogen applied at different levels in spring to S.170 tall fescue grown in wide drills did not significantly affect the number of fertile tillers per unit area in 1957 ; high nitrogen rates increased the barren tiller population and significantly reduced the yield of seed.

The effects of gibberellic acid on growth habit and heading in grass varieties (J.L.S.)

Grass varieties showed differences in their capacity to respond to repeated applications of gibberellic acid in terms of vegetative yield.

There was no evidence that gibberellic acid could overcome the daylength or cold requirements for flowering of the varieties tested, nor accelerate the flowering process in S.48 timothy which appears to have no cold requirement.

THE EFFECTS OF GIBBERELLIC ACID ON GROWTH HABIT AND HEADING IN RED CLOVER (*Trifolium pratense L.*) (J.L.S.)

The main effect of the gibberellic acid treatment of red clover during the year of sowing was to reduce the number of tillers, increase internode length and produce fewer leaves than in the control; it also gave nearly double the number of flowers in red clover and a proportionately increased seed yield. Recovery after cutting was more rapid in the treated plants, and as a result the aftermath seed crop of the late-flowering red clover was harvested earlier; the production of two crops of bloom in the same season thus becomes a distinct possibility for typical single-cut varieties.

Seedling plants of S.123 red clover sprayed at stages up to the seventh trifoliate leaf developed into single stem types but a progressive increase in number of stems followed later sprayings, which also stimulated branching on the lower stem nodes. Plants sprayed during later growth stages had the earliest head emergence dates and also the greatest number of heads. *First harvest year plants* sprayed at stages up to the production of the eighth extended internode on the older stems showed a decrease in stem number, but secondary and tertiary branching was again stimulated by G.A. at all stages. The suppression of basal growth noted in plants sprayed before internode elongation was correlated with greater subsequent extension of the basal internode, and also with inhibition of branching on the lower stem nodes. No significant advancement of blossom emergence was noted in these plants and the maximum increase in the number of flowers per plant was only 3%, thus indicating that more than one spraying may be necessary to obtain maximum stimulation.

THE EFFECT OF CALCIUM LEVEL ON THE UPTAKE OF NITROGEN BY HERBAGE GRASSES (J.L.S.)

With increasing amounts of nitrogen applied in spring, three grass varieties, S.48 timothy, S.143 cocksfoot and S.215 meadow fescue, grown in pots showed a progressive increase in vegetative and fertile tiller production. The response to nitrogen was not significantly altered by the addition of lime applied at the rate of $2\frac{1}{2}$ or 5 tons $CaCo_3$ per acre.

A STUDY OF SEED DEVELOPMENT IN VARITIES OF TIMOTHY (*Phleum pratense* AND *Phleum nodosum L.*) IN RELATION TO TIME OF HARVEST (J.L.S.)

Results from an experiment on different dates of harvesting seed after full anthesis show that certain varieties of timothy can be harvested relatively earlier than others without unduly affecting germination or the weight of 1,000 seeds. The diploid variety of timothy S.50 (*P. nodosum*) provided a different curve from the two hexaploid varieties S.48 and S.51. These curves, together with the germination data, suggest that more latitude could be allowed at harvest time than is generally realised, and that satisfactory control of pre-harvest seed shattering might be achieved by earlier harvesting.

The large number of small heads present in the three varieties appeared to be derived from the later-formed tillers induced by spring nitrogen. Although these small heads represented about 30% of those present in a population, their contribution to the total seed crop was only approximately 16%, which indicates that an assessment of the effect of spring nitrogen on the seed crop in terms of total number of heads produced would not be valid.

EFFECT OF MANAGEMENT ON STABILITY (G.E.)

The evidence suggests that management of a seed crop influences the stability of a variety. When seed crops of some grass varieties were harvested late, the inflorescence emergence in the next generation appeared to be delayed by comparison with that of plants grown from crops harvested early. In tall fescue, for example, the proportion of taller plants decreased and shorter plants increased after late harvesting, and tall plants were more numerous from heavy seed rates than from spaced plants.

Defoliation at the time of inflorescence formation, as a pretreatment of leafy cocksfoot varieties, seemed to cause a delay in inflorescence emergence in the next generation. Delay in flowering, however, was not apparent in the early heading varieties of perennial ryegrass, timothy and meadow fescue subjected to the same treatment.

THE EFFECT OF OTHER SPECIES ON SEED PRODUCTION OF OATS AND GRASSES (J.L.)

The data from pot experiments show that the yield of oat grain is depressed by cut-leaved cranesbill, docks and white clover at high and low seed rates for the cereal. The least reduction in yield occurred at low seeding in the absence of nitrogen.

	Relative yields of oat grain							
	No nitrochalk				Nitrochalk 3 cwt. per acre			
	Control	White clover	Cranes-bill	Docks	Control	White clover	Cranes-bill	Docks
High density	100	46.4	38.8	33.6	100	60.5	48.9	56.6
Low density	100	94.4	95.0	92.5	100	89.0	75.0	62.8

The dry matter yield in timothy and meadow fescue in the seeding year was depressed by docks, cranesbill and soft bromegrass, but white clover did not appear to have this effect to any great extent. Vegetative tiller numbers in both timothy and meadow fescue were unaffected.

Seed viability studies (J.L.)

Seeds of weeds, cultivated herbage species and cereals continued to show high germination after storage for six years at 32°F. while most of those held in the granary failed to survive. Species differed in their reaction to storage in the soil ; e.g. timothy seeds had 86% vitality after six years at a depth of 10″ while most of the other grass seeds had disintegrated.

Results of investigations on seed survival during short periods in the soil suggest that soil water level is an important factor, seeds of most species had largely germinated after two months when held above the water table, while those at the same soil depth but below the water table remained dormant, and were highly viable in subsequent laboratory tests. Vitality was better maintained in the autumn than in the summer.

The influence of cereal dressings on germination and yield of oats (J.L.)

Observations on the germination of oat grains treated with Gamma B.H.C. revealed considerable retardation of root growth accompanied by severe distortion, particularly seeds germinating on filter pads, but marked reduction also occurred in sand and vermiculite cultures. Relative root growth after eight days was as follows :

		Dressings		
	Control	Normal (2 oz. per bushel)	Double	Triple
Filter pads	100	29.1	10.8	7.7
Sand	100	47.2	44.5	28.6
Vermiculite	100	46.6	40.9	29.0

When the seed was sown in soil the treatment did not adversely affect the yield of grain from two varieties of oats, as shown by the following data :

		Dressings		
	Control	*Normal* (2 *oz. per bushel*)	*Double*	*Triple*
S.221	100	94	109	95
S.220	100	107	121	124

CYTOLOGY

KEITH JONES

STUDIES IN *Dactylis*

The close co-operation continues between cytologist and breeder in the study of *Dactylis*. The basic survey of plant collections is complete, but all new introductions are being checked, including new F.A.O. collections and samples from Russia. No diploids have been found other than those previously reported.

An intensive analysis is being made of triploid hybrids in *Dactylis*. These hybrids represent crosses between *D. glomerata* ($2n = 28$) and its diploid subspecies *woronowii*, *aschersoniana* and *lusitanica*, and between *D. maritima* ($2n = 28$) and the subspecies mentioned. In the cross *D. glomerata* × ssp. *judaica*, with the diploid as female parent, six plants have been analysed ; the data obtained confirm the lack of appreciable chromosome differentiation in *Dactylis*. Detailed results of these studies will be published in the near future.

Information is being collected on chromosome numbers and behaviour in the progenies of triploid *Dactylis* hybrids crossed as female with diploid and tetraploid males. The results show that the most successful gametes produced by the triploid are those with 13 or 14 chromosomes, so that the bulk of the progenies have $2n = 20$, 21, 27 and 28. However, about one-third of the progeny of the cross 3x × 2x has $2n = 14$, showing that an $n = 7$ gamete will often succeed, whereas in the cross 3x × 4x it is never successful. Indeed, some progeny plants from the latter cross have $2n = 34$, 35, 36 or 37. This differential success of the 7 gamete in the diploid cross brings to mind the ease of a 4x × 2x cross (= 14 + 7) compared with the reciprocal 2x × 4x (= 7 + 14). It is important to check upon chromosome pairing in the euploid progenies of these crosses with triploids, and so far meiosis has been observed to be regular in the 14 and 28 chromosome plants, though the latter show a tendency towards fewer quadrivalents and chiasmata per p.m.c. than is usual in a tetraploid. Nevertheless, there is every hope that triploid crosses can produce new combinations of the parental chromosomes at both diploid and tetraploid levels, with a simultaneous restoration of fertility.

CHROMOSOME COUNTS IN *Phalaris* S.230

A variety of *Phalaris* S.230 has been bred at the Station from an original hybridization of *Phalaris arundinacea* ($2n = 28$) with

Phalaris tuberosa ($2n = 28$). Although the F_1 was only partially fertile subsequent breeding has produced a highly fertile variety. Chromosome counts have revealed that S.230 is now hexaploid ($2n = 42$); the figures below show the frequency of chromosome numbers in a sample:

	Frequency distribution					*Total*	*Per cent*
	$2n = 40$	41	42	43	44	*plants*	*hexaploid*
Accurate counts	13	10	94	7	1	125	75.2
Approximate counts	6	1	18	2	–	27	66.6

Counts made on some plants of an early generation confirm 28 as the chromosome number of the original material. It must be presumed that unreduced gametes have functioned at some stage in the breeding programme so accounting for the present chromosome number, and the improvement in fertility. The relatively high frequency of aneuploids found in S.230 is due to irregularities at meiosis.

Miscellaneous chromosome counts

Many chromosome counts were made during 1956/57 on colchicined material of *Lolium italicum* × *Festuca arundinacea*. In the genus *Phleum*, counts of the open-pollinated progeny of a triploid plant of *Phleum nodosum* showed that most plants possessed the chromosome number of the pollen parents ($2n = 14$), whilst a few had $2n = 18$, or 19. Both *Anthoxanthum amarum* and *Alopecurus alpinus* were found to be 16-ploid, with $2n =$ c. 80 and $2n =$ c. 112 respectively.

Karyotype investigations in *Anthoxanthum*

To facilitate the study of chromosome morphology in *Anthoxanthum* tiller plants were rooted in jars of culture solution. Although they were supplied with a nutrient solution adequate in all respects for *Lolium* some of the plants became chlorotic, and one granule of I.C.I. complete fertilizer was added to each jar whenever the solutions were changed. Startling improvements occurred in colour and vigour of both root and shoot, so that given this treatment the plants could remain indefinitely in the jars. The ample and constant supply of roots made it possible to obtain more data on chromosome morphology than hitherto, and, at least with regard to the SAT chromosomes, it now seems that there is much variation in morphology and some variation in number not correlated with populations as such. Marked intraspecific variation appeared in the annual diploid forms

of *Anthoxanthum* where the number of SATs ranged from 2 to 7. As this study progressed it seemed that much of the material consisted of derivatives of a cross between a 2-SAT diploid and a 6-SAT diploid such as *A. aristatum*. On inquiring about this possibility at the Botanic Garden, Uppsala, where all the material originated, it was found that two such species were grown next to each other, and that the seeds could well be hybrid. This experience shows the limited value of some botanic garden material, and underlines the importance of collecting in the field whenever possible.

As reported earlier, the tetraploid *A. odoratum* ($2n = 20$) is a permanent interchange heterozygote. The evidence suggests that its permanence is due not so much to selection for favourable gene blocks, as to polyploidy *per se*. F_1 hybrids of what are here considered to be the ancestors of this tetraploid show considerable interchange pairing which, if chromosome doubling were to follow, would at once produce the situation presently observed.

Cytotaxonomy of *Holcus*

In order to obtain evidence on the origin, relationship and taxonomic position of *Holcus lanatus* ($2n = 14$), and the races of *H. mollis* ($2n = 28, 35, 42, 49$), two experiments have been designed to measure their morphological characters, together with those of the triploid hybrids produced by crossing *H. lanatus* with *H. mollis* ($2n = 28$). Both experiments have a randomised block layout, the replication being clonal throughout. The data which have been collected are not yet fully analysed, but results so far confirm the lack of any good taxonomic character for separating the races of *mollis*, though the pentaploid seems to diverge in the direction of *lanatus* in certain vegetative features. The triploid hybrids vary according to the parents used. Of the three progenies examined one is intermediate between *mollis* and *lanatus* vegetatively, the second tends more towards *mollis*, and the third resembles *mollis* closely. In spikelet characteristics the *mollis* features predominate.

This report has been prepared by Mr. Christopher Carroll on behalf of Dr. Keith Jones, who is at present abroad.

CHEMISTRY SECTION

Routine analytical work has again increased, the number of Kjeldahl determinations alone having now risen to 10,000 per annum.

Study of chemical and other characters of cereal straw (G.ap G., and D.C.T.)

In 1956 five varieties of oats differing in straw characteristics were sown and each was subjected to nitrogen, phosphate and potash fertilizer treatments. In 1957 further field trials were carried out on Victory oats to study the effect of fertilizers, shading and differing seed rates on the resistance to lodging and chemical composition of the straw. In addition, a pot experiment was set up using a soil low in available phosphate and potash, to study more closely the effect of phosphate and potash fertilizers. Lodging resistance measurements and chemical analyses were carried out in all trials. No consistent relationship was found to exist between resistance to lodging and any single chemical component, apart from nitrogen, either between varieties or within one variety.

Fertilizers did not improve standing ability above that of the unfertilized plants, even when the soil was low in available phosphate and potash. Nitrogen decreased the resistance to lodge, the degree of reduction varying with both time of application and environmental conditions.

High seed rates and shading reduced lodging resistance, the effect of the latter was most striking, it lengthened the stem, considerably weakened the plant, and markedly influenced the chemical composition of the straw, causing an increase in the percentage normal-acid fibre, crude protein and ash constituents. A decrease in resistance was observed immediately after heading and thereafter the straw increased in strength until maturity.

A detailed soil survey of the experimental land at Gogerddan (M.H.)

The object is to produce detailed maps, showing microtopography and soil properties. A chain survey of the land was first made and base maps on a scale 50 ft. to 1 in. have been prepared ; additional details have been recorded which will enable larger scale maps to be made later if required.

A contour survey followed and this is now nearly complete. Vertical intervals of 1 ft. have been used on the more level part of the estate, and of 2 ft. on the steeper slopes. On the flatter land small

changes in the microrelief will be important in determining the water table level, and possibly in reflecting changes in soil texture.

The next step will be soil sampling at 50 ft. intervals; note will be taken of parent material, drainage, depths, texture, structure and stoniness, and the samples will be analysed for organic matter, total nitrogen, pH, and exchangeable phosphorus, potassium and calcium.

Normal-acid fibre content of herbage

During 1956/57 the normal-acid fibre method was applied to the study of eight grasses, as single plants and as swards, manured and unmanured, at two centres, one at about sea level and the other at an altitude of 750 ft. The grasses were S.23 and S.24 perennial ryegrass, S.48 and S.50 timothy, S.143 cocksfoot, S.170 tall fescue, S.59 creeping red fescue, and *Agrostis* Br.616. The results showed marked and consistent differences between species and between varieties. The fibre content of manured herbage was generally higher than for unmanured, and for herbage grown as single plants than for that grown in swards. Whether the variations in fibre content between species and varieties are large enough to result in differences of economic importance in digestibility must be the subject of further enquiry.

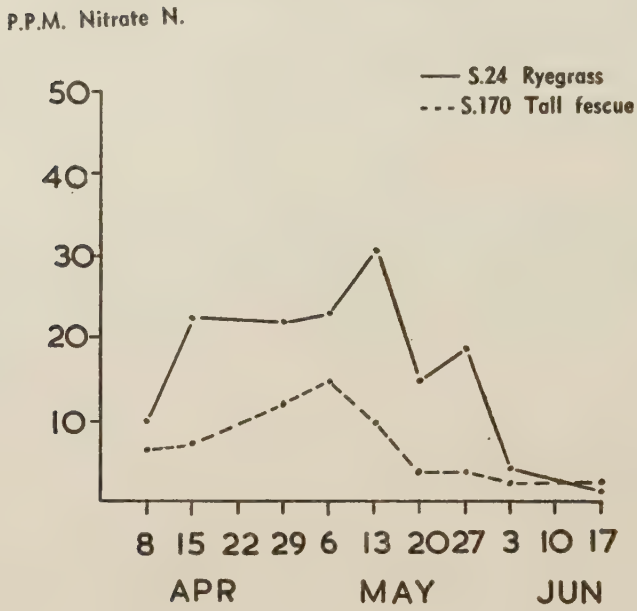
Investigation showed that there is no critical date after which fibre increased, but rather that there is a steady rise in fibre content from the beginning of the season.

A large number of determinations were made to examine laboratory and plot-to-plot variation; both field variation and laboratory errors were found to be low compared with species and variety differences.

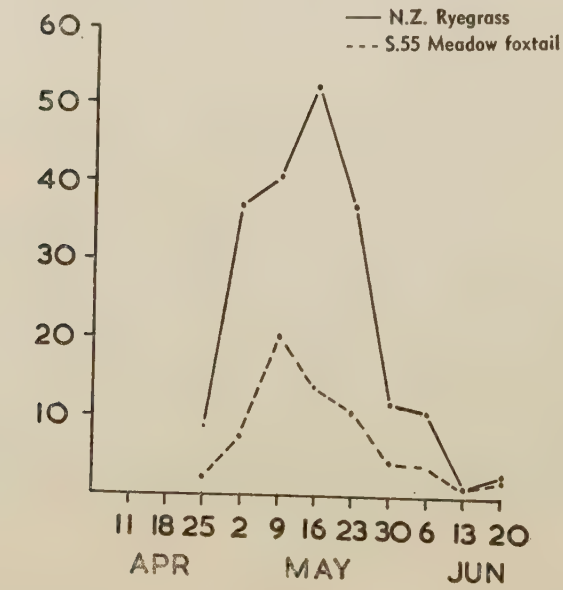
Effect of grass species on the nitrate content of soil following the ploughing up of a ley

Previous observations made at this Station indicated that the growth of crops following a grass ley varied with the grass species forming the foundation of the ley. During 1957 two ley experiments comparing different grass species were ploughed up and planted with oats. From an early stage in the growth of the oats on Cae Glas Bach following a four-year ley, great differences were visible in vigour and in colour between the plots which had previously carried different grass species. Two plots, one of S.24 perennial ryegrass and one of S.170 tall fescue were examined to see whether the visible effects could be correlated with soil nitrate nitrogen. On another

CAE GLAS BACH
GOGERDDAN. Altitude 80 ft.



LANE FIELD
FRONGOCH. Altitude 400 ft.



site two plots were examined, one of New Zealand ryegrass and one of S.55 meadow foxtail, after a six-year ley. Both were sites of replicated experiments but for the purpose of this investigation two adjacent plots only were sampled at each site.

The accompanying graph shows the nitrate nitrogen on the two pairs of plots from the two sites. The superiority of nitrate N in the plot which had previously carried a ryegrass ley is clearly demonstrated, and the difference in nitrate content agreed with the performance of the oats in each case.

The nitrate N curves are of course the expression of production of nitrate N by the soil, less consumption by the oat crop, and other losses. The peaks thus represent the time when consumption overtook and finally exceeded production. It is important to realise that the peaks of these curves do not necessarily correspond either with the maximum of nitrate production or consumption, which are in fact probably reached much later.

It is interesting that the peaks of the ryegrass curves are on the same date at the two sites. Those of the tall fescue and meadow foxtail fall on the same date as each other, but a week earlier than the ryegrass, an expression of the smaller amount of nitrate N which had been more quickly consumed.

Non-protein nitrogen factor of herbage species

In the first place the intention was only to record some typical true protein percentages for the different classes of herbage which pass through the laboratory. Preliminary results, however, soon shifted the focus of interest to mineral nitrate content, which was found to be surprisingly high in some circumstances.

The present results seem to indicate a tendency for nitrate nitrogen to accumulate (at a fairly high level of the artificial nitrogen applied) in the early summer and in the autumn. The first date may be associated with a check in growth, accompanied by a check in the nitrogen metabolism due to water deficiency, the second to the seasonal slowing down of growth. Both suggestions need examination and further data are being accumulated.

The feature of most interest to plant breeders is the variation in nitrate content shown by different species and varieties of the same species. There is a suggestion here of some fundamental physiological differences. Nitrate is lethal in its effects in comparatively small amounts. What may be important is the effect of sub-lethal quantities on milk yield or live weight gains.

BRIEF DESCRIPTION OF THE NEW VARIETY OF WINTER OATS, PENRHYN S.234

This new variety of winter oats is of composite origin and is derived from a series of crosses with intervening selection and re-selection, the sequence of which was as follows: (a) Marvellous × Grey Winter (1924); (b) F_{10} selection ex (a) × Unique (1934); (c) F_4 Selection ex (b) × S.147 (1938), followed by repeated selection and re-selection during seven succeeding seasons. The final head-selections were made in 1948, of which, after seed increase, the more promising were tested in small-scale yield trials during 1951/52, and 1952/53 at Aberystwyth, and in preliminary trials by the National Institute of Agricultural Botany at Cambridge.

Following these initial tests two of the most promising of the new varieties were chosen for continuation in a series of field trials by the N.I.A.B. At the conclusion of these trials the variety carrying the reference number V1022, and now designated Penrhyn S.234, was recommended for inclusion in the Provisional List of Recommended Varieties of Winter Oats.

The chief aim in the breeding and selection of this new variety was to secure a winter oat with a higher yielding capacity than S.147, suitable in length and strength of straw for soils of moderate to good fertility.

Agronomic features

In the National Institute of Agricultural Botany official trials conducted over several seasons, Penrhyn S.234 has consistently outyielded S.147 by a substantial margin. The two varieties are very similar in tillering capacity, resistance to frost and strength of straw, but the straw of Penrhyn S.234 is slightly shorter, and the panicles are slightly heavier and more compact. There are small differences in time of maturity, the new variety being about five days later in ear emergence, and about three days later in ripening. The grain of Penrhyn S.234 is white and of good size, and although slightly longer is, like that of S.147, of good feeding quality.

Morphological features

Panicle open, medium to large in size, carrying numerous two-grained spikelets which are well distributed and give the panicle an attractive well-balanced and distinctive appearance. The panicle branches are somewhat weak and tend to droop as the grain develops and ripens. Spikelets are generally two-grained, three-grained and

single spikelets being rare. The grain is white, of medium size, somewhat pointed and occasionally awned. The lower grain has two small lateral tufts of short hairs at its base.

Husk percentage	= 23–26%
Weight per 1,000 grain	= 36–38 gm.

RECOMMENDATION

The new variety is recommended for soils on which S.147 has proved satisfactory, and it is proposed to make a first distribution of seed in the autumn of 1958.

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